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Geotechnical Instrumentation Plan for May Creek Bridge Replacement Pile Driving

WSDOT I-405 Renton to Bellevue Design-Build

Renton to Bellevue, Washington

Project # PS19-20316-0

Prepared for:

Flatiron-Lane Joint Venture

Prepared by:

Wood Environment & Infrastructure Solutions, Inc.
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December 23, 2021

Wood Environment & Infrastructure, Inc.
12/23/2021 (Date) DQAM Initials
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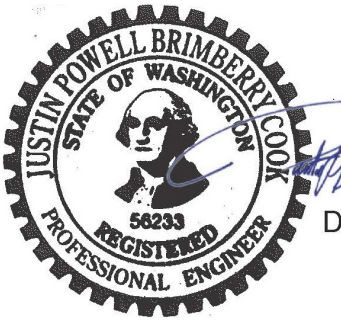

December 23, 2021

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List of appendices

List of acronyms

Flatiron-Lane	Flatiron-Lane Joint Venture
GIP	Geotechnical Instrumentation Plan
I-405	Interstate 405
in/sec	inches per second
PPV	peak particle velocity
RFP	Request for Proposal
Wood	Wood Environment & Infrastructure Solutions, Inc.
WSDOT	Washington State Department of Transportation

1.0 Introduction

This report has been prepared in support of the Washington State Department of Transportation (WSDOT) Interstate 405 (I-405) Renton to Bellevue Design-Build project, in accordance with the requirements presented in the I-405 Renton to Bellevue Widening Project Request for Proposal (RFP), specifically Section 2.6.7.5, and the applicable sections of the WSDOT *Geotechnical Design Manual* (WSDOT 2015).

This report provides a Geotechnical Instrumentation Plan (GIP) for pile driving as part of the May Creek Bridge Replacement. Deep pile foundations will be installed for the new south and north bridge piers. Based on Drawings BG25E6 and BG25W6 (Appendix A-1), there will 28 piles for the northbound piers and 30 piles for the southbound piers, consisting of 30-inch outside diameter and 0.625-inch wall thickness hollow pipe piles. Wood Environment & Infrastructure Solutions, Inc. (Wood) understands that the existing bridge at May Creek must remain in operation while the new bridge is constructed in stages to allow continuous traffic flow.

2.0 Requirements for Geotechnical Instrumentation Plan

Section 2.6.7.5 of the I-405 Renton to Bellevue Widening Project RFP requires that geotechnical instrumentation be installed and used to monitor the following:

1. Sensitive facilities;
2. Temporary shoring;
3. Settlement and settlement rates on embankments and structures where settlements are predicted to be greater than 2 inches;
4. Pore water pressures for staged embankment construction;
5. Groundwater levels (if dewatering is used);
6. Ground and structure vibrations when impact or vibratory methods are used for installation of shaft casings or driving piling; and
7. Vibration levels for freshly placed concrete in conformance with Section 6-02.3(6)D of the WSDOT Standard Specifications (WSDOT 2018).

Wood and Flatiron-Lane Joint Venture (Flatiron-Lane) previously prepared two GIPs to address construction around the May Creek Bridge that is not associated with pile driving:

- A GIP for settlement monitoring of early works fill construction (Wood 2021), and
- A GIP for monitoring of the temporary shoring work for soil nail wall 7.10R (Flatiron-Lane 2021).

These two GIPs address embankment settlement monitoring for new embankments in the northbound lanes and temporary shoring monitoring in the northbound lanes. Embankments are also currently under geotechnical design for the southbound lanes. GIPs addressing embankment settlement will be provided as necessary as these embankments are designed.

This GIP is provided primarily to address ground and structure vibration and settlement monitoring during pile driving for the May Creek Bridge replacement. Wood understands that both impact and vibratory methods shall be used to drive the piles; thus, this GIP addresses conditions 1 and 6 of RFP Section 2.6.7.5.

3.0 Sensitive Facilities

Existing sensitive facilities near the May Creek Bridge pile installation are shown in Appendices A-2 and B, and described below:

- ***Water lines:*** There is one line extending approximately north-south between the new south abutment piles and one line extending east-west approximately 25 feet north of the south abutment.
- ***Storm sewers:*** There is one line extending north-south between the new piles near the west end of both the south and north abutments, one line running east-west approximately 45 feet south of the south abutment, and one line running north-south near the west end of the north abutment.
- ***Underdrain lines:*** There is one line running north-south between the piles at the east end of the south abutment and one line running north-south between the piles at the east end of the north abutment.

- ***Sanitary sewer:*** A 36-inch-diameter King County Wastewater Treatment Division sewer line runs east-west approximately mid-way between the proposed south and north bridge abutments. The sanitary sewer is approximately 75 feet from proposed pile driving.
- ***Private sanitary side sewer:*** The private sewer consists of a 6-inch polyvinyl chloride pipe and is located west of the south bridge abutment.
- ***Existing May Creek Bridge structure***.

4.0 Vibration During Pile Driving

4.1 Expected Vibrations from the Pile Installation

Wood understands that Flatiron-Lane intends to drive piles with an AP200-6 Vibratory Hammer and will complete driving with a Delmag D62-22 Impact Hammer. We used the *Transportation and Construction Vibration Guidance Manual* (Caltrans 2013) to estimate the peak particle velocity (PPV) ground vibrations at various distances from the AP200-6 Vibratory Hammer and Delmag D62-22 Impact Hammer, given below:

AP200-6 Vibratory Hammer

- For distance (D) = 10 feet, PPV = 2.1 inches per second (in/sec),
- For D = 20 feet, PPV = 0.9 in/sec,
- For D = 40 feet, PPV = 0.4 in/sec, and
- For D = 80 feet, PPV = 0.15 in/sec.

Delmag D62-22 Impact Hammer with an energy rating of 78,920 to 165,215 ft-lbs

- For D = 10 feet, PPV = 3.2 to 4.6 in/sec,
- For D = 20 feet, PPV = 1.3 to 1.9 in/sec,
- For D = 40 feet, PPV = 0.5 to 0.8 in/sec, and
- For D = 80 feet, PPV = 0.2 to 0.3 in/sec.

Appendix A-2 provides the horizontal offsets for the above estimated screening assessment vibrations from pile installation.

The values provided above will be adjusted based on field measurements of PPV.

4.2 Utilities and Drainage

Based on discussions with industry experts internal to Wood and our review of the Piling and Shoring Supplementary Specification of the Standards for Designing and Constructing City Infrastructure (City of Toronto 2017), we understand that without specific assessments for each utility, the PPV for the utilities should be at or below the following threshold levels to avoid damage:

- Modern (newer) sewer/watermains: 1-inch-per-second PPV, and
- Older sewer/watermains: ½-inch-per-second PPV.

Flatiron-Lane shall review the estimated screening assessment vibrations for the pile installation (given in Section 4.1 and Appendix A-2) and prepare a supplement to this GIP describing the proposed testing, inspection, and potential repair plan for the utilities/drainage listed in Section 3.0.

4.3 Existing Bridge Structure

The following Alert and Action Levels will be used for the existing bridge:

- An Alert Level will be initiated if the measured vibration reading during pile driving exceeds a PPV of 3.5 inches per second. After the Alert Level is initiated, a qualified representative will visually inspect the bridge once per day until completion of the pile driving.
- An Action Level will be initiated if the measured vibration during pile driving reading exceeds a PPV of 5.0 inches per second. If an Action Level is initiated, a qualified representative will visually monitor the bridge continuously during the pile driving. The qualified representative will check for defects, cracking, and unusual conditions caused by the pile driving. If any of these conditions are observed, the pile driving will stop

immediately, and the Contractor will adjust the driving methods. The Contractor will develop a corrective action plan that will be submitted to WSDOT for review and approval.

The PPV values in the bullet list above were developed by using the maximum PPV and minimum corresponding concrete compressive strength data presented in the WSDOT Standard Specifications Section 6-02.(6)D2 (WSDOT 2018). The detailed methodology is presented in Appendix A-3.

Adjacent traffic may cause noise in the monitoring, so a minimum of three readings associated with the driving of a single pile within an interval of two minutes at the Alert or Action Levels shall be recorded to initiate an Alert or Action Level.

4.4 Vibration Monitoring of the Existing Bridge Structure

Vibration monitoring of the existing bridge structure shall consist of manual vibration monitoring geophones capable of measuring vibrations from 0.02 inch to 10 inches per second in a frequency range of 2 to 250 hertz. The product data sheet for the geophones is provided in Appendix C. The geophones should be placed on the bridge structure within 5 feet of the abutments at the locations shown on the drawings in Appendix B; however, at any one time, only the two locations closest to the pile installation need to have vibration monitoring.

Prior to the start of the pile driving, geophones shall be placed at the various planned locations in order to conduct vibration monitoring for two days to establish the vibration baseline from existing traffic.

During pile driving, geophones shall be placed at the planned locations prior to the start of pile driving each day and collected for charging and data transfer at the end of each day. If a pile is not fully driven in one day, then the geophone locations shall be marked at the end of the day and the geophones will be placed in the same location the following day. Vibration monitors shall continuously collect data during pile installation. As discussed in Section 4.3, the Alert Level will be initiated if the vibrations exceed 3.5 inches per second and the Action Level will be initiated if the vibrations exceed 5.0 inches per second.

4.5 Preconstruction/Postconstruction Surveys

Prior to the start of pile driving, a preconstruction survey of the existing bridge shall be done. The preconstruction survey of the existing bridge will be in accordance with RFP Section 2.6.7.3.

Following the completion of the pile driving, a post-construction survey shall be done to document the condition of the bridge.

5.0 Settlement Monitoring of the Existing Bridge

Based on RFP Section 2.6.7.5, we note that settlement monitoring is only required if the settlements are predicted to be greater than 2 inches. Since the settlements of the existing bridge due to pile driving are anticipated to be small, settlement monitoring is not required. Please refer to the existing bridge settlement estimate calculations that are presented in Appendix D. Therefore, no settlement action and alert levels are required.

However, settlement monitoring points will be placed at the locations shown in Appendix B and will be in place with a base line reading one week prior to the start of the pile installation. The monitoring points will consist of optical monitors as described in Section 7.1 of this GIP. Alternatively, a FlatMesh Triaxial Tilt Sensor Node that communicates through a wireless monitoring system can be used. The monitoring will be continuous with an equipment accuracy of 0.01 foot (0.12 inch). The product data sheet is provided in Appendix C.

In addition to the settlement monitoring, Flatiron-Lane will conduct a pre-condition visual inspection of the existing bridge.

6.0 Instrumentation and Monitoring Data Reports

Reports summarizing instrumentation and optical monitoring data collection (see example reports in Appendix E) will be submitted by Flatiron-Lane to the Structural Engineer within one business day of collection, and a summary of monthly activity will be provided within the first week of the following month. For the optical monitoring, the surveyor shall identify locations of benchmarks, located at least 100 feet away. The instrumentation and optical monitoring reports will be posted to Procore and hard copies will be available as requested. These reports will include:

- A summary of the day's work that notes the work being performed on site and time that the data was collected or optical survey monitoring was conducted;
- Observations that will help describe the instrumentation data and optical survey monitoring for that day;

- A copy of the cumulative instrumentation and optical monitoring raw data (see example in Appendix E); and
- Plots representing the cumulative instrumentation and optical monitoring data (see example in Appendix E).

All instrumentation and monitoring data reports will be transmitted on a monthly basis to WSDOT via email unless the vibration Alert Level or Action Level monitoring threshold is breached. WSDOT, the Construction Quality Assurance Manager, the Geotechnical Group Manager, and other relevant stakeholders will be notified within 24 hours.

7.0 Equipment and Surveyor Qualifications

7.1 Equipment

The contractor shall furnish all labor and materials and perform all operations required for the installation, protection, and maintenance of the geophone and the optical survey. Instruments that are damaged or fail will be replaced immediately. No construction work will take place until the instruments are replaced.

All optical monitoring surveys (or sensor node readings) will be performed at the frequencies defined in this document and to an accuracy of 0.01 foot (0.12 inch). A calibrated instrument shall be used and calibration certificates shall be provided. A permanent survey benchmark shall be established away from the zone of influence subject to fill placement; on undisturbed, natural ground; and protected from construction equipment disturbance. The zone of influence for settlement monitoring points should be at least 100 feet away. The zone of influence for vibration monitoring is determined to be at least 150 feet away. Results of the vibration and survey monitoring shall be provided to the Structural Engineer to determine if the monitoring should be continued and to review the frequency of monitoring. The data will be put into a report.

We propose to install the following instrumentation and use the following survey equipment on site:

- Sigicom Infra C12 Wireless Triaxial Vibration Monitor or similar;
- Trimble S7 Total Station or equivalent;
- Trimble DiNi Digital Level or equivalent; and
- As an alternative, FlatMesh Triaxial Tilt Sensor Nodes can be used in place of the optical survey.

Data sheets for all proposed equipment and calibration certificates for the survey equipment are presented in Appendix C. Calibration sheets for the vibration monitoring geophones will be provided by the manufacturer with the delivery of the equipment and will be issued as an addendum to this report. All instrumentation shall be installed per the manufacturers' instruction manual.

Vibration monitors that are damaged or fail for any reason will be replaced immediately. If the monitors cannot be replaced immediately, the construction activities within the zone of influence that were monitored by the instrumentation will cease until the vibration monitors are replaced and fully operable.

7.2 Surveyor

The survey work will be conducted under the direction of Keith Craig Moore. Craig has more than 40 years of experience in the surveying field. His experience includes geometry control for fabrication and erection of precast concrete segments. Craig has held a supervisory position in the construction industry for 30 years. He has a record of success overseeing surveying on multimillion-dollar heavy civil, infrastructure, and commercial development projects for government and private-sector clients. Craig's resume is presented in Appendix F. Craig will be assisted in the field by:

- ***Jay McCombs:*** Jay's monitoring experience includes railroad monitoring for bridge installation, excavation shoring, building structure and foundation monitoring. Jay has 16 years of experience.
- ***Trevin Sada:*** Trevin has 30 years of experience and has performed monitoring for various types of balance cantilever bridges, excavation pile walls, railroad monitoring, public and private utilities, and various types of structures.
- ***Sigurd Sorensen:*** Sigurd has performed monitoring for high-rise excavation and construction, settlement monitoring for mass grading, and long-term settlement monitoring. Sigurd has five years of experience.

8.0 References

California Department of Transportation (Caltrans). 2013. *Transportation and Construction Vibration Guidance Manual*. Report No. CT-HWANP-RT-13-069.25.3.

City of Toronto. 2017. Piling and Shoring – GN117SS Supplementary Specification. In *Standards for Designing and Constructing City Infrastructure*. April.

Flatiron-Lane Joint Venture (Flatiron-Lane). 2021. Geotechnical Instrumentation Plan for RW 7.10R TSNW. February 23. Submittal No. 929.

Washington State Department of Transportation (WSDOT). 2015. *Geotechnical Design Manual*. Publication M46-03.11.

WSDOT. 2018. *Standard Specifications for Road, Bridge, and Municipal Construction*. Publication M 41-10.

Wood Environmental & Infrastructure Solutions, Inc. (Wood). 2021. Geotechnical Instrumentation Plan for Settlement Monitoring – Early Works Fill Construction. In association with Flatiron-Lane Joint Venture. January 28. Submittal No. 973.

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Appendix A
Pile Details and Estimated Screening Assessment Vibrations from Pile Installation

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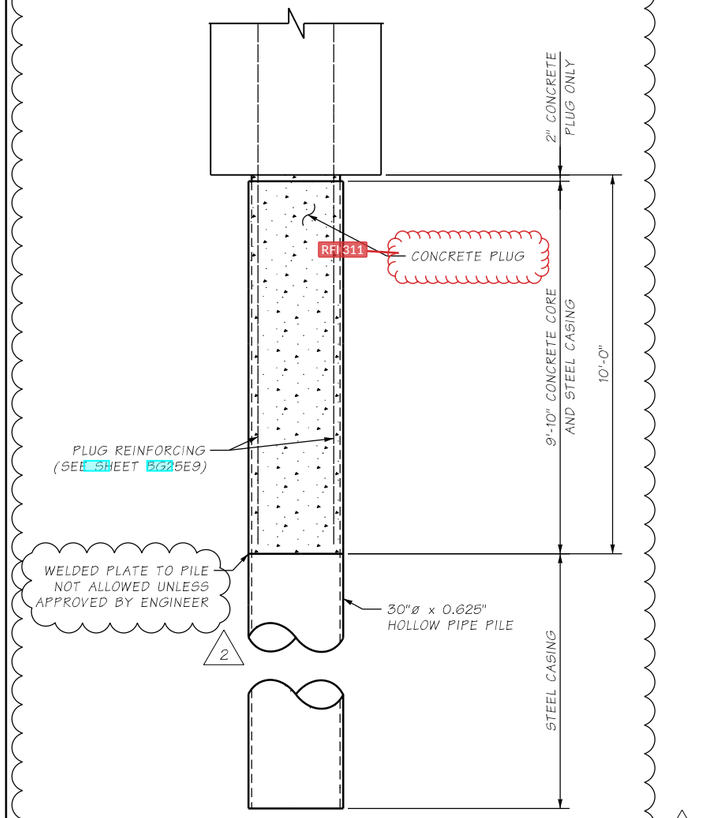
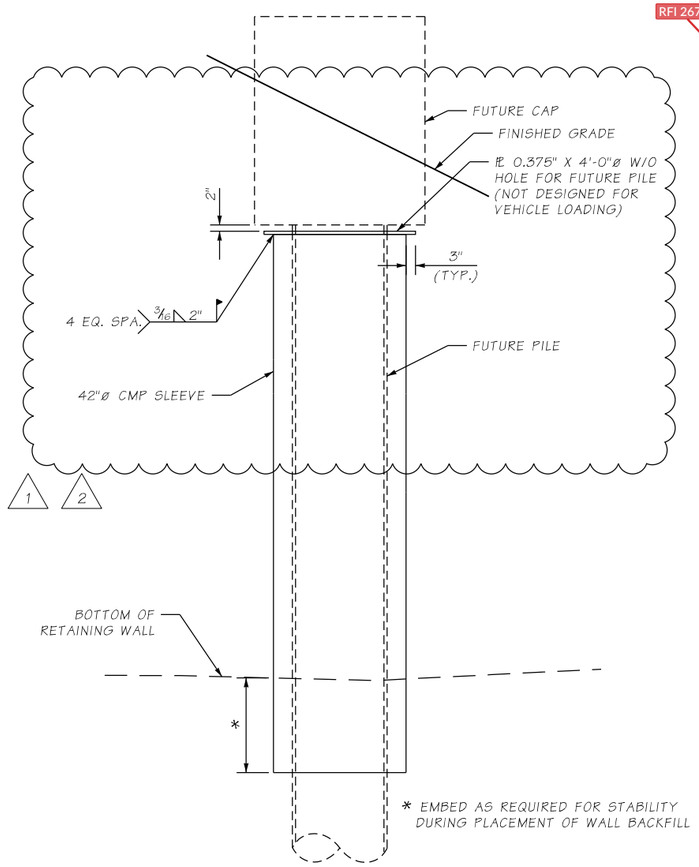
Appendix A-1
Pile Details



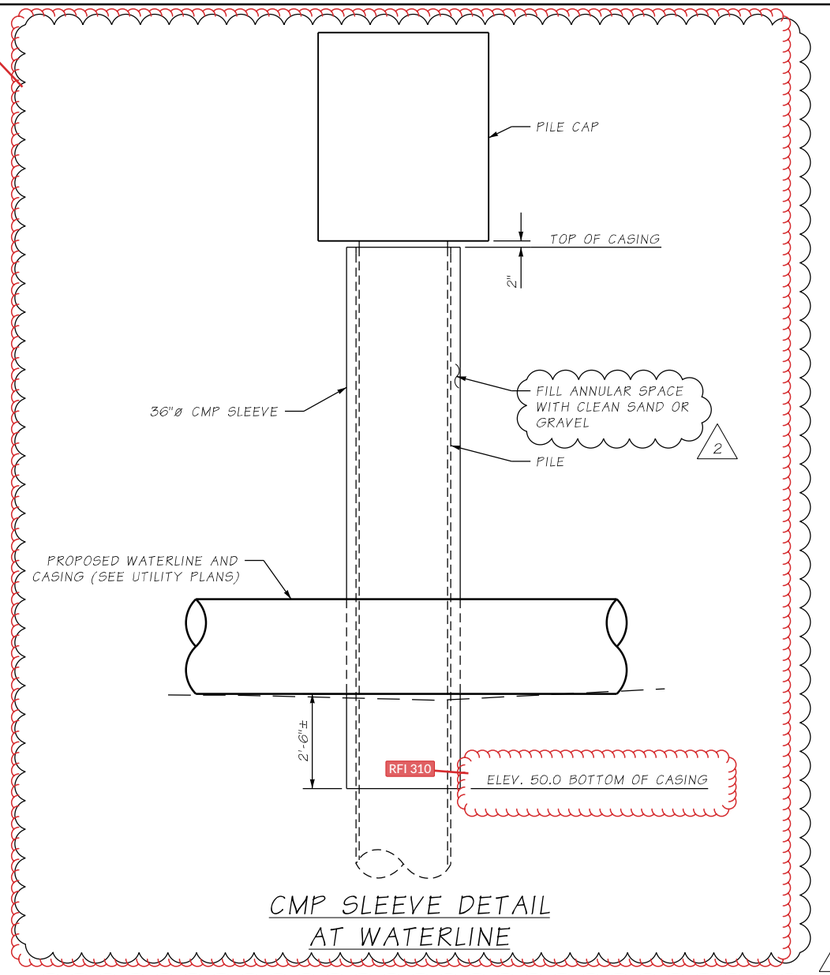
PILE ELEVATION

1



CMP SLEEVE DETAIL
FUTURE WIDENING

RFI 267



CMP SLEEVE DETAIL
AT WATERLINE

1

PIER	PILE DIAMETER (D) IN.	NUMBER OF PILES	STEEL THICKNESS (T) IN.	MIN. PILE TIP ELEV.	ESTIMATED TIP ELEV.	MIN. BEARING CAPACITY (KIPS)	REQUIRED DRIVING RESIST R_{ndr} (KIPS)
1	30	13	5/8	26.0	15.0	761	827
2	30	15	5/8	20.0	10.5	724	792

2 1

1. PILE DYNAMIC TESTING (PDA) SHALL BE PERFORMED PRIOR TO PRODUCTION PILE DRIVING TO ESTABLISH PILE DRIVING CRITERIA. SUBSEQUENTLY, PRODUCTION PILE DRIVING CAN BE TERMINATED WHILE MEETING THE PILE DRIVING CRITERIA AND HAVING THE PILE TIP REACH AN ELEVATION NO HIGHER THAN THE SPECIFIED MINIMUM TIP ELEVATION SHOWN ON THE PLAN. IN CASES THAT PILE DRIVING ENCOUNTERS REFUSAL AT AN ELEVATION HIGHER THAN THE REQUIRED MINIMUM PILE TIP ELEVATION, GEOTECHNICAL AND STRUCTURAL ENGINEERS SHALL BE INFORMED TO EVALUATE AND DETERMINE IF THE PILE IS ACCEPTABLE.
2. "MIN. BEARING CAPACITY" IS THE MINIMUM ULTIMATE BEARING CAPACITY REQUIRED. R_{ndr} IS THE REQUIRED NOMINAL PILE DRIVING RESISTANCE DURING TEST PILE PDA TESTING (ULTIMATE BEARING CAPACITY PLUS OVERDRIVING).
3. "MIN. BEARING CAPACITY" SHOWN IS FOR STRENGTH 1 WITH DOWNDRAG INCLUDED.
4. STEEL PILES SHALL CONFORM WITH THE CHEMICAL COMPOSITION REQUIREMENTS OF ASTM A709 GRADE 50.
5. STEEL PILE FABRICATION AND MATERIAL TESTING SHALL CONFORM TO SECTION 6-05.3(5).0PT1.GB6 OF THE GENERAL SPECIAL PROVISIONS IN APPENDIX B3 OF THE CONFORMED RFP.
6. STEEL PILE SPLICES SHALL CONFORM TO SECTION 6-05.3(6).0PT1.GB6 OF THE GENERAL SPECIAL PROVISIONS IN APPENDIX B3 OF THE CONFORMED RFP.

2 2

2

CMP SLEEVE NOTES:

1. MATERIALS:
   - A. CMP CAP PLATES SHALL BE MADE OF HOT DIP GALVANIZED AASHTO GRADE 36 STEEL.
   - B. CMP SLEEVES SHALL BE GALVANIZED AASHTO M36 14 GA. PER STANDARD SPECS 9-05.4 AND THE QPL 9-05.4 - PIPE - STEEL - STEEL CULVERT AND PIPE ARCH (UNTREATED).
   - C. ANNULAR SPACE BETWEEN SLEEVES AND PILES SHALL BE FILLED WITH AGGREGATE THAT MEETS THE REQUIREMENTS OF 9-03.12(4) GRAVEL BACKFILL FOR DRAINS OR 9-03.13 BACKFILL FOR SAND DRAINS.
2. CONSTRUCTION REQUIREMENTS:
   - A. AT WATERLINE
     1. SET CMP SLEEVES AT THE SAME TIME THE WATERLINE IS INSTALLED.
     2. STABILIZE THE CMP SLEEVES TO MAINTAIN PROPER ALIGNMENT.
     3. FILL THE LOWER 4 FEET OF THE SLEEVES WITH AGGREGATE.
     4. CONSTRUCT EMBANKMENT TO TOP OF SLEEVES.
     5. DRIVE PILES. ENSURE THE INSIDE SLEEVE IS NOT CLOSER THAN 2 INCHES FROM THE STEEL PILE. RFI 414
     6. AFTER PILE DRIVING, FINISH PLACING THE FILL MATERIAL IN THE ANNULAR SPACE BETWEEN THE SLEEVES AND PILES IN LIFTS NOT TO EXCEED 2 FEET FOR THE REMAINING SLEEVE LENGTH. ROD OR VIBRATE EACH LIFT TO PREVENT VOIDS.
     7. CONSTRUCT PIER CAP AND REMAINDER OF BRIDGE.
   - B. FUTURE WIDENING
     1. STABILIZE THE SLEEVES TO MAINTAIN PROPER ALIGNMENT.
     2. FILL THE LOWER 4 FEET OF THE SLEEVES WITH AGGREGATE.
     3. PLACE AND COMPACT THE SEW BACKFILL.
     4. INSTALL STEEL COVER PLATES. WELDING PROCEDURES SHALL BE IN COMPLIANCE WITH THE CURRENT AASHTO/AWS D1.5 BRIDGE WELDING CODE.
     5. BACKFILL OVER COVER PLATE. DO NOT USE HEAVY EQUIPMENT TO PLACE OR COMPACT BACKFILL.

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12/10/2020
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DESIGNED BY:	ANURAG JAIN	ADDED CMP SLEEVE NOTES AND UPDATED NOTES	12/02/2020	2	
ENTERED BY:	RANDY ARTMAN				
CHECKED BY:	GREG GRIFFIN				
DQAM AUDIT DATE:					
DESIGN MGR:	TOM NETTLETON	DESCRIPTION	DATE	NO.	

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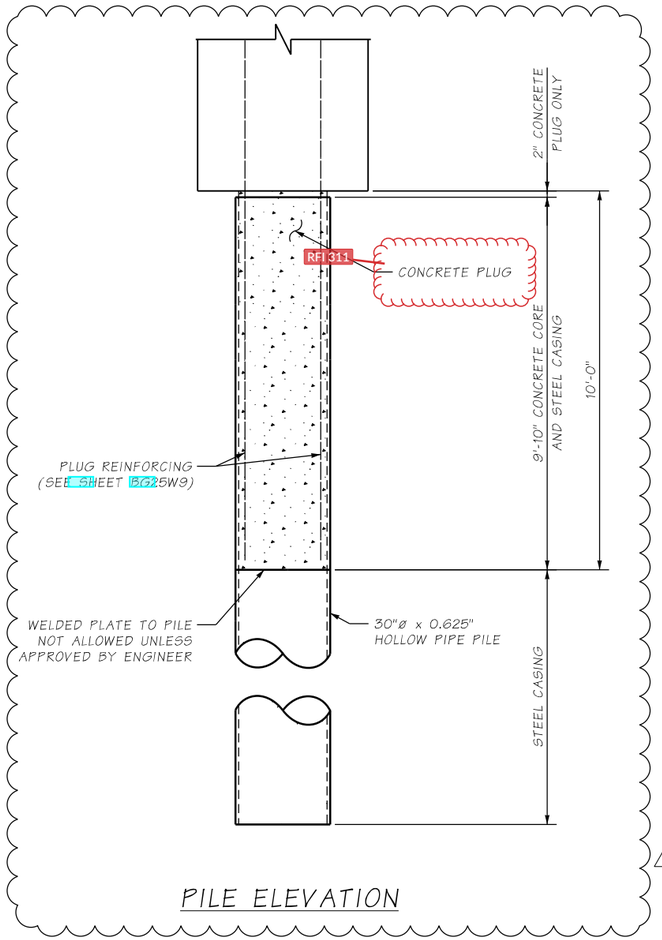
I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT
I-405 NB OVER MAY CREEK

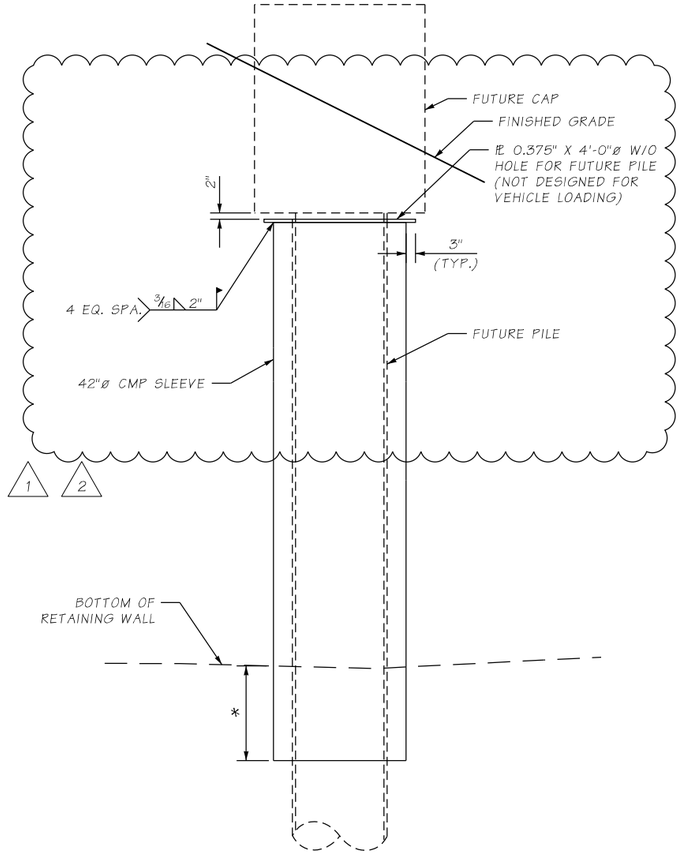
PILE DETAILS

PLAN REF NO BG25E6

SHEET 6 OF 29 SHEETS



PILE ELEVATION



* EMBED AS REQUIRED FOR STABILITY DURING PLACEMENT OF WALL BACKFILL

CMP SLEEVE DETAIL
FUTURE WIDENING

PIER	PILE DIAMETER (D) IN.	NUMBER OF PILES	STEEL THICKNESS (T) IN.	MIN. PILE TIP ELEV.	ESTIMATED TIP ELEV.	MIN. BEARING CAPACITY (KIPS)	REQUIRED DRIVING RESIST R_{ndr} (KIPS)
1	30	15	5/8	23.0	14.0	782	838
2	30	15	5/8	20.0	6.5	723	787

2 1

1. PILE DYNAMIC TESTING (PDA) SHALL BE PERFORMED PRIOR TO PRODUCTION PILE DRIVING TO ESTABLISH PILE DRIVING CRITERIA. SUBSEQUENTLY, PRODUCTION PILE DRIVING CAN BE TERMINATED WHILE MEETING THE PILE DRIVING CRITERIA AND HAVING THE PILE TIP REACH AN ELEVATION NO HIGHER THAN THE SPECIFIED MINIMUM TIP ELEVATION SHOWN ON THE PLAN. IN CASES THAT PILE DRIVING ENCOUNTERS REFUSAL AT AN ELEVATION HIGHER THAN THE REQUIRED MINIMUM PILE TIP ELEVATION, GEOTECHNICAL AND STRUCTURAL ENGINEERS SHALL BE INFORMED TO EVALUATE AND DETERMINE IF THE PILE IS ACCEPTABLE.
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3. "MIN. BEARING CAPACITY" SHOWN IS FOR STRENGTH 1 WITH DOWNDRAG INCLUDED.
4. STEEL PILES SHALL CONFORM WITH THE CHEMICAL COMPOSITION REQUIREMENTS OF ASTM A709 GRADE 50. 2
5. STEEL PILE FABRICATION AND MATERIAL TESTING SHALL CONFORM TO SECTION 6-05.3(5).0PT1.GB6 OF THE GENERAL SPECIAL PROVISIONS IN APPENDIX B3 OF THE CONFORMED RFP.
6. STEEL PILE SPLICES SHALL CONFORM TO SECTION 6-05.3(6).0PT1.GB6 OF THE GENERAL SPECIAL PROVISIONS IN APPENDIX B3 OF THE CONFORMED RFP.

2

CMP SLEEVE NOTES:

CMP SLEEVE NOTES:
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   - B. CMP SLEEVES SHALL BE GALVANIZED AASHTO M36 14 GA. PER STANDARD SPECS 9-05.4 AND THE QPL 9-05.4 - PIPE - STEEL - STEEL CULVERT AND PIPE ARCH (UNTREATED).
2. CONSTRUCTION REQUIREMENTS:
   - A. STABILIZE THE SLEEVES TO MAINTAIN PROPER ALIGNMENT.
   - B. PLACE AND COMPACT THE SEW BACKFILL.
   - C. INSTALL STEEL COVER PLATES. WELDING PROCEDURES SHALL BE IN COMPLIANCE WITH THE CURRENT AASHTO/AWS D1.5 BRIDGE WELDING CODE.
   - D. BACKFILL OVER COVER PLATE. DO NOT USE HEAVY EQUIPMENT TO PLACE OR COMPACT BACKFILL.

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Washington State Department of Transportation
FLATIRON LANE wood

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT
I-405 SB OVER MAY CREEK

PILE DETAILS

PLAN REF NO BG25W6
SHEET 6 OF 29 SHEETS

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Appendix A-2
Estimated Screening Assessment Vibrations from Pile Installation

WORK ZONE MG1

ESTIMATED SCREENING ASSESSMENT VIBRATIONS FOR THE PILE INSTALLATION BASED ON CALTRANS (2013)

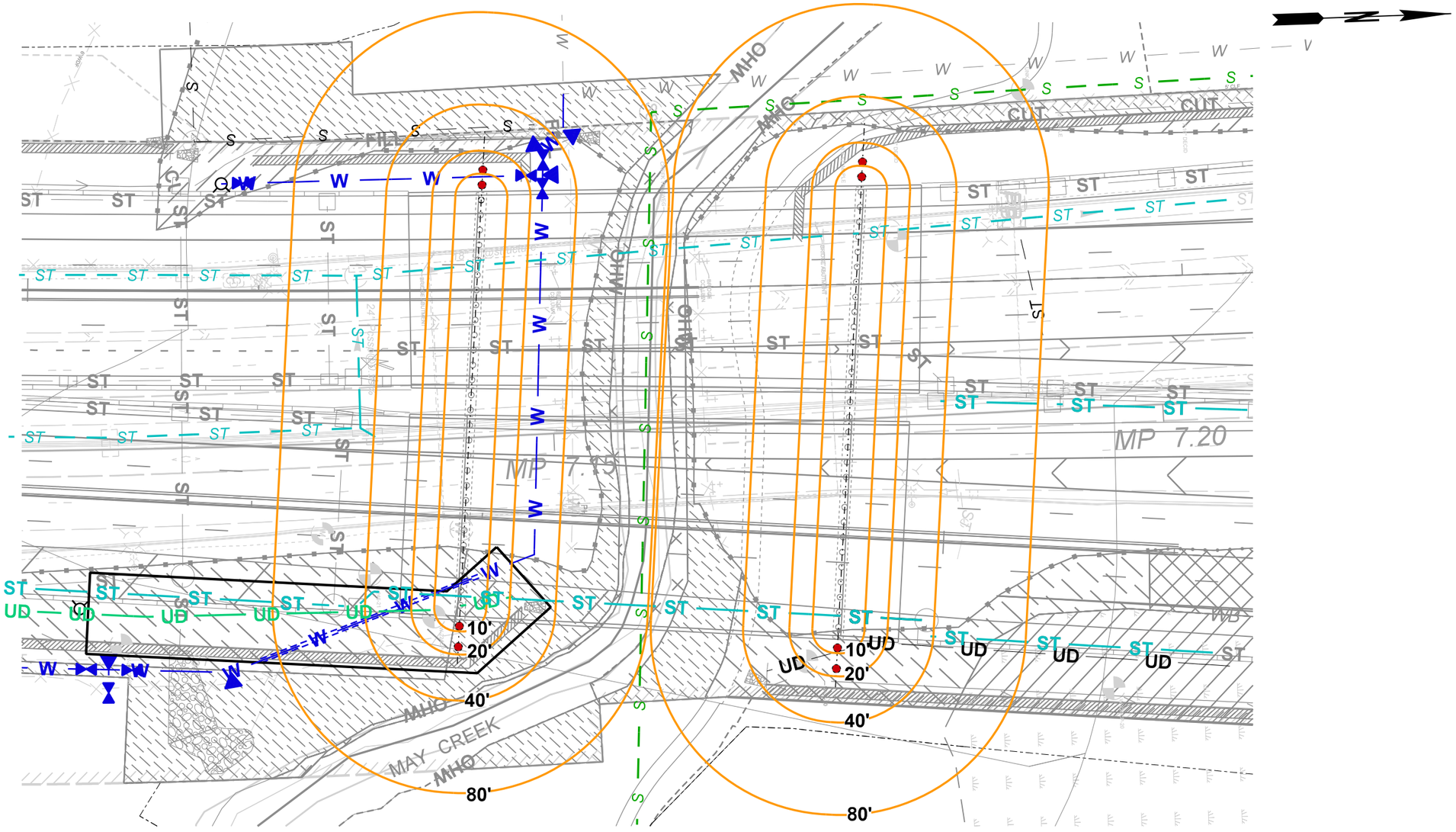
PEAK PARTICLE VELOCITY (PPV) FOR THE VIBRATORY HAMMER AND IMPACT HAMMER ARE AS FOLLOWS:

FOR THE AP200-6 VIBRATORY HAMMER, THE ESTIMATED SCREENING ASSESSMENT VIBRATIONS ARE AS FOLLOWS

FOR D = 10 FT, PPV = 2.1 IN/SEC
FOR D = 20 FT, PPV = 0.9 IN/SEC
FOR D = 40 FT, PPV = 0.4 IN/SEC
FOR D = 80 FT, PPV = 0.15 IN/SEC

FOR THE DELMAG D62-22 HAMMER WITH AN ENERGY RATING OF 78,920 TO 165,215 FT-LBS, THE ESTIMATED SCREENING ASSESSMENT VIBRATIONS ARE AS FOLLOWS

FOR D = 10 FT, PPV = 3.2 TO 4.6 IN/SEC
FOR D = 20 FT, PPV = 1.3 TO 1.9 IN/SEC
FOR D = 40 FT, PPV = 0.5 TO 0.8 IN/SEC
FOR D = 80 FT, PPV = 0.2 TO 0.3 IN/SEC



ESTIMATED SCREENING ASSESSMENT VIBRATIONS FOR THE PILE INSTALLATION BY RANDY HILLABY, WOOD.

LEGEND

OFFSET LINE FOR THE ESTIMATED SCREENING ASSESSMENT VIBRATIONS FROM THE PILE INSTALLATION. OFFSET LINES DO NOT TAKE INTO CONSIDERATION FUTURE FORWARD COMPATIBILITY PILES AT THE LOCATION OF THE CMP SLEEVES.

- S - EXISTING SANITARY SEWER LINE
- W - NEW WATER LINE
- W - EXISTING WATER LINE
- UD - UNDERDRAIN
- ST - STORM LINE

CORRUGATED METAL PIPE (CMP) SLEEVES WILL BE INSTALLED FOR FUTURE FORWARD COMPATIBILITY PILES.

FILE NAME	c:\users\patrick.mccarthy\documents\projectwise\workingdir\wsdot\dms24179\MAY CREEK SCREENING ASSESSMENT.dgn				REGION NO.	STATE	FED.AID PROJ.NO.
TIME	10:28:19 AM				10	WASH	
DATE	10/19/2021				JOB NUMBER		
PLOTTED BY	patrick.mccarthy						
DESIGNED BY	X. XXXXXXXX						
ENTERED BY	P. MCCARTHY						
CHECKED BY	R. HILLABY				CONTRACT NO.		LOCATION NO.
PROJ. ENGR.	T. WENTWORTH						
REGIONAL ADM.	S. WOODRUFF	REVISION	DATE	BY			

P.E. STAMP BOX — DATE

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Washington State Department of Transportation

FLATIRON LANE

wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT
MAY CREEK BRIDGE

ESTIMATED SCREENING ASSESSMENT VIBRATIONS FROM PILE INSTALLATION

PLAN REF NO

SHEET OF SHEETS

FLATIRON | LANE

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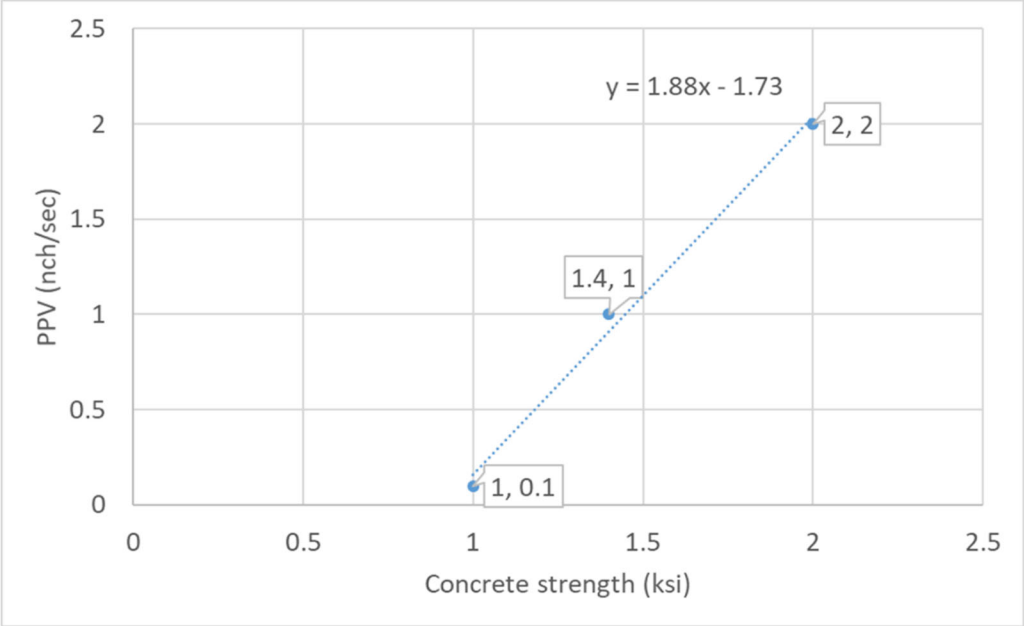
Appendix A-3
Vibration Monitoring Approach

May Creek Vibration Monitoring Approach

1) Conduct preconstruction survey of existing bridge condition.
2) Set up vibration monitoring equipment a couple days in advance to establish vibration baseline from existing traffic.
3) PPV alert/action levels
    a. WSDOT 6-02.(6)D2

Minimum Compressive Strength, f'c	Maximum PPV
< 1,000 psi	0.10 in/sec
1,000 to < 1,400 psi	1.0 in/sec
1,400 to 2,000 psi	2.0 in/sec

Standard Spec values provide a linear correlation between strength and PPV. Using this correlation for existing design f'c=3.6 ksi, the predicted PPV=5 in/sec (1.88*3.6-1.73=5.04 in/sec)



5.0 in/sec will be used as the action level for response. The alert level will be set lower at 3.5 in/sec.

4) During Driving:
    a. Alert Level (3.5 in/sec): If the driving PPV exceeds 3.5 in/sec, then a qualified representative visually inspect the existing the bridge once per day after completion of pile driving.
    b. Action Level (5.0 in/sec) If PPV exceeds 5 in/sec, then a qualified representative will visually monitor the existing bridge continuously for the remainder of driving. If cracking is observed, work will stop immediately, and the Contractor will adjust the driving methods.
5) Conduct post-construction survey to document bridge condition.

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Appendix B
Vibration and Settlement Monitoring Locations for the Existing May Creek Bridge During the Pile Installation

WORK ZONE MG1

LEGEND

- SETTLEMENT MONITORING LOCATION
- VIBRATION MONITORING LOCATION*

* AT ANY TIME ONLY THE TWO CLOSEST VIBRATION MONITORING POINTS TO THE PILE INSTALLATION REQUIRE MONITORING.

MONITORING SHOULD BE DONE AT THE LOCATIONS SHOWN WITH FIELD FIT ADJUSTMENTS TO MONITOR THE STRUCTURAL ELEMENTS IN THE MOST APPROPRIATE WAY.

FILE NAME	c:\users\patrick.mccarthy\documents\projectwise\workingdir\wsdot\dms24179\MAY CREEK ASSESMENT.dgn				REGION NO.	STATE	FED.AID PROJ.NO.
TIME	12:56:05 PM				10	WASH	
DATE	11/1/2021				JOB NUMBER		
PLOTTED BY	patrick.mccarthy						
DESIGNED BY	M. SABBAGH						
ENTERED BY	P. MCCARTHY						
CHECKED BY	R. HILLABY				CONTRACT NO.		LOCATION NO.
PROJ. ENGR.	J. COOK						
REGIONAL ADM.	S. WOODRUFF	REVISION	DATE	BY			

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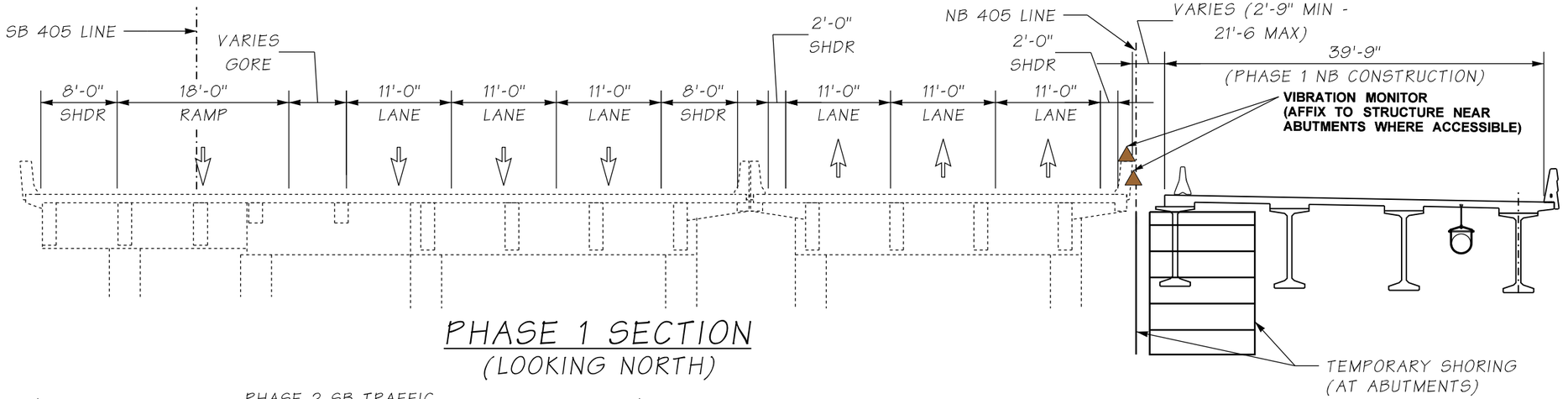
I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT MAY CREEK BRIDGE

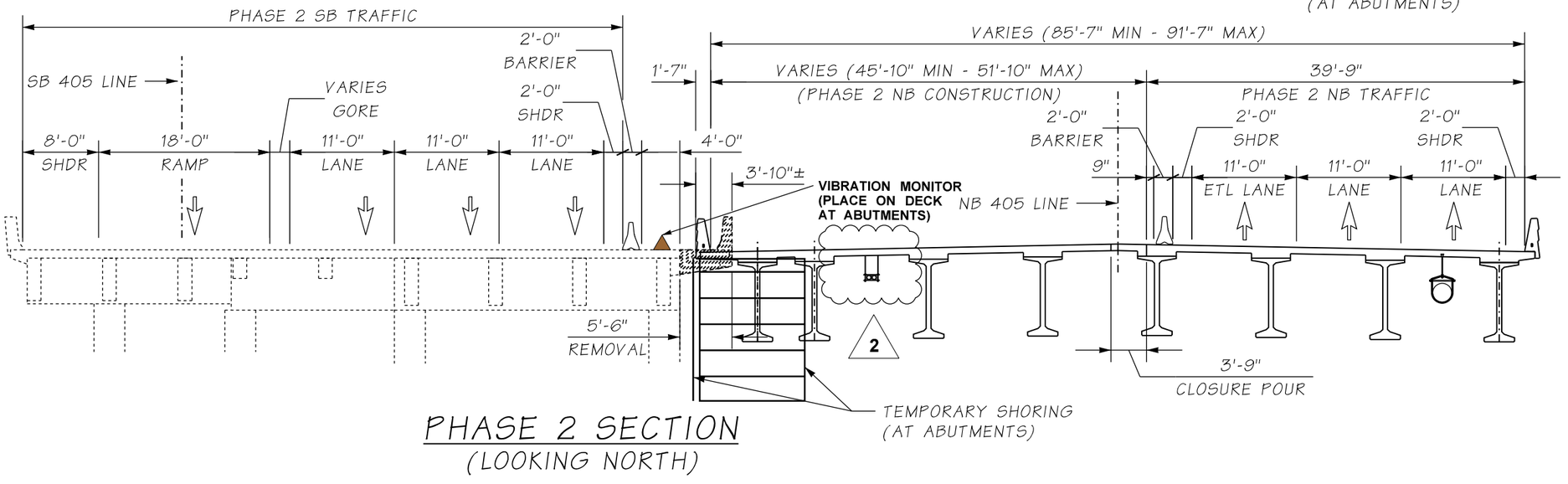
VIBRATION AND SETTLEMENT MONITORING LOCATION FOR THE EXISTING MAY CREEK BRIDGE DURING THE PILE INSTALLATION

PLAN REF NO

SHEET OF SHEETS



PHASE 1 SECTION
(LOOKING NORTH)



PHASE 2 SECTION
(LOOKING NORTH)

LEGEND

▲ VIBRATION MONITORING LOCATION*

* AT ANY TIME ONLY THE TWO CLOSEST VIBRATION MONITORING POINTS TO THE PILE INSTALLATION REQUIRE MONITORING.

MONITORING SHOULD BE DONE AT THE LOCATIONS SHOWN WITH FIELD FIT ADJUSTMENTS TO MONITOR THE STRUCTURAL ELEMENTS IN THE MOST APPROPRIATE WAY.

FILE NAME	c:\users\patrick.mccarthy\documents\projectwise\workingdir\wsdot\dms24179\MAY CREEK ASSESSMENT-VIBRATION.dgn				REGION NO.	STATE	FED.AID PROJ.NO.
TIME	12:49:05 PM				10	WASH	
DATE	11/1/2021				JOB NUMBER		
PLOTTED BY	patrick.mccarthy						
DESIGNED BY	M. SABBAGH						
ENTERED BY	P. MCCARTHY						
CHECKED BY	R. HILLABY				CONTRACT NO.		LOCATION NO.
PROJ. ENGR.	J. COOK						
REGIONAL ADM.	S. WOODRUFF	REVISION	DATE	BY			

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT
MAY CREEK BRIDGE

VIBRATION MONITORING LOCATION FOR THE EXISTING MAY CREEK BRIDGE DURING THE PILE INSTALLATION

PLAN REF NO

SHEET OF SHEETS

FLATIRON | LANE

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wood.

Appendix C
Instrumentation Data Sheets and Calibration Certificates

Sigicom

INFRA C12

COMPLETE WIRELESS VIBRATION MONITOR FOR THE INFRA SYSTEM

INFRA C12 Wireless Triaxial Vibration Monitor

The INFRA system is used to monitor construction activities, blasting, train traffic, road traffic, vibration in buildings etc.

- **Built in GSM/GPRS modem**
- **3–4 weeks of continuous running time on the internal batteries**
- **Simultaneous bargraph, waveform registration and live data**
- **All in one compact unit**
- **Watertight (IP67)**
- **Full remote control**

INFRA C12 is a Triaxial geophone and a data logger built into the same compact unit.
All filtering, signal processing and detection is done digitally. Before the recording is started you only select the wanted standard that is presented in the Remote part of INFRA Net.

The INFRA C12 works with INFRA Net the same way as the other INFRA sensors and data loggers.

INFRA C12 measures according to the following national and international standards:

ISEE Seismograph, 2 –250 Hz

ISEE/USBM, 2-250 Hz [mm/s]

DIN 4150-3 Anlage, 1-315 Hz

DIN 4150-2 KB, 1-80 Hz

BS 7385, 1-300 Hz

AS 2187-2 2006, 2-250 Hz

ÖNORM S 9012, 1-80 Hz

ISO 8569 Acceleration, 5-300 Hz

IN1226, 1 – 150 Hz

NS 8176 Komfort, 1-80 Hz

NS 8141 Byggverk, 5-300 Hz

NS 8141-1:2012 + A1:2013, 3-400 Hz

SS 4604866 Spräng, 5-300 Hz

SS 025211 Schakt, 2-150 Hz

SS 4604861 Komfort, 1-80 Hz

Geophone, 5-500 Hz

ICPE–Cirkulaire 86, 1-150 Hz

Turkey - Mining and Quarry, 2-250 Hz

Technical Data

DIRECTION OF SENSITIVITY

C12 is triaxial and measures vibration in three directions.

MEASURING

The unit has a built in digital signal processor. The signal processor processes all incoming data in real time according to the selected standard. The unit works in combinational mode. It measures maximum values for each interval (selectable from 5 sec. to 20 min) according to the selected standard and at the same time it triggers and record time histories when the trigger level is exceeded.
DIN 4150-3, ISEE, BS 7385, AS 2187-2 and ISEE/USBM also measures the frequency of the peak value in each interval.

SAMPLING

The geophone signal is sampled at 4096 Hz using a high resolution A/D converter which gives a wide dynamic range. When a preset threshold is exceeded a time history is recorded. Even some time before the trigger time is stored (pre-trig).

RECORDING TIME

Recording time up to 40 seconds at 4 kHz sampling.

POWER SUPPLY

Internal lithium-Ion batteries that easily can be changed through a separate battery cover. It is possible to connect an external battery eliminator and connect to an external power source e.g. solar panel, 12VDC Lead Acid battery. In sunny conditions the built in solar panel charges the internal batteries.

MEASURING RANGE

Frequency range 1 Hz - 500 Hz The Geophone has a calibrated sensitivity within +- 2%. Maximum vibration level is 250 mm/s dependent on the selected standard.

SENSOR ELEMENT

The sensor element is a high quality velocity sensing geophone. It is very rugged and has the following properties:
- **Long term stability**
- **Wide temperature range**
- **Wide dynamic range**

IDENTITY

The unit has a unique ID number that follows the recorded data. This makes it possible to trace data to a certain unit.

MEMORY

CompactFlash memeory card typ II. 256 MB standard.

DATA TRANSFER

All data files are buffered in a "spool directory" on the memory card and are sent when the next GSM communication takes place. If GSM communication is not possible data are stored for transfer at a later time.

DATA SMS

INFRA C12 can send an SMS to a number of cell phones with data from a triggered event.

SERVICE SMS

SMS can be sent directly from INFRA C12 to service personnel when battery voltage is low, if sensors are lost/disconnected or when memory is close to full.

CALIBRATION

The unit has an internal memory for identity, calibration factors, calibration date etc.

REMOTE OPERATION

Unit settings can be changed from any PC using INFRA Net and an Internet connection.

MECHANICAL & ENVIRONMENTAL

Watertight anodized aluminium house with rubber seals. It has a hole for bolts passing through in horisontal direction for wall mount.
Dimension: 140 x 100 x 60 mm (5.5 x 3.9 x 2.3 in)
(excluding antennas, connector and standoffs)
Material: Anodized aluminium.
Protection class IP67
Weight: 1800 grams (4.0 lbs)
Operating temperature: –20 to + 50 °C (-4 to 122 °F)

CE APPROVAL

Fulfills EMC demands according to:
EN 301 489-1 V1.8.1 (2008)
EN 301 489-7 V1.3.1 (2005)
EN 61326-1 (2006)

Doc. nr DS089_D4212-EnG

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Sigicom

CALIBRATION DOCUMENT

Document No:	Print Date:	Location of Calibration:	Page No:
Cal 76535	9/16/2020	Fort Collins, CO, USA	1 / 1

Customer: Morgner Construction Management

Device under Test: INFRA C22 Triaxial Vibration Monitor
SN: **101682**
Software Version: 2.3.0.1079

Date of Calibration: 9/16/2020

Ambient Conditions: 23° C ± 2° C (73.4° F ± 3.6° F)

Method of Measurement: C311xB.
(Reference frequency: 80Hz (16Hz), frequency sweep: 1-1000 Hz)

Equipment: Digital Multimeter: Agilent 34411A #MY48006192
Vibration System: Modal Shop K2075E040 #679
Reference Amplifier: B&K 2525 #2863966
Signal Generator: Agilent 33521A #MY50003837
Reference Accelerometer: B&K 4381 #30896
Climate Sensor: Comet T7510 #12963114

Traceability: Reference equipment is calibrated at accredited laboratories, traceable to NIST, PTB or other National Metrology Laboratory.

Result of Measurement: Results are within specification limits of the method, which includes the hardest demands of all standards available in the geophone.

Recommended Interval of Calibration: 12 months.

Calibration performed by: Brett Sharp **Signature:** Brett Sharp .....

Sigicom

CALIBRATION DOCUMENT

Document No:	Print Date:	Location of Calibration:	Page No:
Cal 79190	2/23/2021	Älvsjö, Sweden	1 / 1

Customer: Morgner Construction Management

Device under Test: INFRA C22 Triaxial Vibration Monitor
SN: **106018**
Software Version: 2.4.0

Date of Calibration: 2/12/2021

Ambient Conditions: 23° C ± 2° C (73.4° F ± 3.6° F)

Method of Measurement: C311xB.
(Reference frequency: 80Hz (16Hz), frequency sweep: 1-1000 Hz)

Equipment:
Reference Accelerometer: B&K 4381 #30964
Reference Amplifier: B&K 2525 #1899363
Digital Multimeter: Keysight 34465A #MY57505160
Climate Sensor: Comet T7510 #16962473
Reference Amplifier: B&K 2525 #2863966
Signal Generator: Agilent 33521A #MY50002998
Vibration System: Modal Shop K2075E-HT #638
Climate Sensor: Comet T7510 #16962465
Digital Multimeter: Agilent 34411A #MY48002643
Reference Accelerometer: B&K 4381 #30896
Signal Generator: Keysight 33521B #MY57700911
Vibration System: Modal Shop K2075E040 #866

Traceability: Reference equipment is calibrated at accredited laboratories, traceable to NIST, PTB or other National Metrology Laboratory.

Result of Measurement: Results are within specification limits of the method, which includes the hardest demands of all standards available in the geophone.

Recommended Interval of Calibration: 12 months.

Calibration performed by: Elanthi Tharma **Signature:** Elanthi Tharma

Sigicom

CALIBRATION DOCUMENT

Document No:	Print Date:	Location of Calibration:	Page No:
Cal 79192	2/23/2021	Älvsjö, Sweden	1 / 1

Customer: Morgner Construction Management

Device under Test: INFRA C22 Triaxial Vibration Monitor
SN: **106019**
Software Version: 2.4.0

Date of Calibration: 2/12/2021

Ambient Conditions: 23° C ± 2° C (73.4° F ± 3.6° F)

Method of Measurement: C311xB.
(Reference frequency: 80Hz (16Hz), frequency sweep: 1-1000 Hz)

Equipment:
Reference Accelerometer: B&K 4381 #30964
Reference Amplifier: B&K 2525 #1899363
Digital Multimeter: Keysight 34465A #MY57505160
Climate Sensor: Comet T7510 #16962473
Reference Amplifier: B&K 2525 #2863966
Signal Generator: Agilent 33521A #MY50002998
Vibration System: Modal Shop K2075E-HT #638
Climate Sensor: Comet T7510 #16962465
Digital Multimeter: Agilent 34411A #MY48002643
Reference Accelerometer: B&K 4381 #30896
Signal Generator: Keysight 33521B #MY57700911
Vibration System: Modal Shop K2075E040 #866

Traceability: Reference equipment is calibrated at accredited laboratories, traceable to NIST, PTB or other National Metrology Laboratory.

Result of Measurement: Results are within specification limits of the method, which includes the hardest demands of all standards available in the geophone.

Recommended Interval of Calibration: 12 months.

Calibration performed by: Elanthi Tharma **Signature:** Elanthi Tharma

Product Data Sheet:
FlatMesh Triaxial Tilt Node

The FlatMesh Triaxial Tilt Sensor Node is an extremely high precision and exceptionally stable three axis tilt sensor which reports its measurements through Senceive's FlatMesh wireless communications network to a FlatMesh Gateway.

Successfully used in many applications, including those measuring:

- Tunnel distortion
- Tunnel heave/settlement
- Embankment slippage
- Structural movement
- Rail track heave/settlement
- Rail trackbed cant and twist

Key features

- Integrated triaxial tilt sensor
- Extremely low noise performance
- Resolution of 0.0001° (0.0018 mm/m) and repeatability of ±0.0005° (±0.009 mm/m)
- Integrated long life battery
- 12-15 year battery life, including when acting as a relay node within the mesh communications network
- Integrated temperature sensor
- Versatile mounting options
- Waterproof to IP66 / IP67 / IP68
- Firmware is remotely upgradeable over the air via the gateway reducing costly site visits

FlatMesh Triaxial Tilt Node

Physical Specifications

Parameter	Value
Dimensions	90 x 90 x 60 mm
Dimensions including vent	90 x 96 x 60 mm
Total Mass	0.6 kg (approx.)
Housing Material	Die cast aluminium body
Internal Protection Marking	IP66 / IP67 IP68 (1 m for 24 hours)
Mounting Options	1/4" UNF holes in bottom, M4 blind holes in side Plates and brackets available for magnetic fixing, trackbed, stake and pole mounting, and many other applications
Operating Temperature Range	-40°C to +85°C

Internal Battery

Parameter	Value
Battery Type	Lithium Thionyl Chloride, non-rechargeable
Nominal Voltage	3.6 V
Nominal Capacity	19000 mAh
Typical Battery Life	12-15 years at 30 minute reporting intervals, including when acting as a relay node. Consult with Senceive for your application.

FlatMesh Triaxial Tilt Node

FlatMesh Radio Specifications

Parameter	Value
Communication Type	Proprietary FlatMesh v3 Mesh Networking Protocols IEEE 802.15.4 compliant
Frequency Band	2400 – 2485 MHz ISM Band
Maximum Transmit Power	6.5 dBm (EN 300 328 v1.8.1)
Maximum Permitted Antenna Gain	2.2 dBi
Range	Up to 300 m depending on the environment and fitted antenna Consult with Senceive for your application
RF Module	Senceive FM3Node

Tilt Sensor Specification

Parameter	Value
Resolution	0.0001° (0.00175 mm/m)
Repeatability (-IX variant)	±0.0005° (±0.0087 mm/m)
Repeatability (-IXH variant)	±0.0025° (±0.0436 mm/m)
Range	±90°

Certifications

- Tested to conformity with all the essential requirements of the Radio Equipment Directive 2014/53/EU and RoHS Directive 2011/65/EU
- FCC Grant of Equipment Authorization
- RCM (Australia and New Zealand)

FlatMesh Triaxial Tilt Node

Ordering Information and Accessories

Model	Description
FM3N-IX	**FlatMesh 3 Triaxial Inclinometer**
FM3N-IXH	**FlatMesh 3 Triaxial Inclinometer (High-g)**
FF-MP-S360	**Swivel mounting kit with 360-degree adjustment range** Screw directly to vertical walls
FF-MP-V	**Vertical mounting plate** Use U-bolts to fix to poles or stakes Use glue to fix to walls where drilling is not permitted (Order with FF-MP-S360)
FF-MP-RA	**Right angle mounting bracket** Screw to concrete tunnel linings and inclined walls (Order with FF-MP-S360)
FF-MP-T2	**Trackbed mounting plate kit**
FF-BK-xxxx **FF-BE**	**Tilt beam kit** See separate datasheet for more information
FA-FM-WPS	**Waterproof straight antenna** Overall node height 168 mm (approx) when fitted Maximum gain +1.1 dBi
FA-FM-LPS	**Waterproof low profile straight antenna** Minimum overall node height, perfect for trackbed and tight spots Overall node height 92 mm (approx) when fitted Maximum gain 0 dBi
FA-FM-ADJ	**Adjustable angle antenna** Flexible installation, perfect for use in tunnels and indoor environments Overall node height 202 mm (approx) when fitted and upright Overall node height 102 mm (approx) when fitted and at 90-degree angle Maximum gain +2 dBi
FC-NC	**Antenna cover kit** Use with FA-FM-LPS antenna Overall node height 96 mm (approx) when fitted

Trimble DiNi

DIGITAL LEVEL

The Trimble® DiNi® Digital Level is a digital height measurement sensor from Trimble's Integrated Surveying™ portfolio of products. The Trimble DiNi is a field-proven tool designed for any job site where fast and accurate height determination is required. Use the Trimble DiNi for applications such as precise leveling of flat and sloping surfaces, establishing the vertical component of grade and ground profiles, subsidence monitoring, and establishing the vertical component of control networks.

UNEQUALLED FOR PERFORMANCE IN THE FIELD

The Trimble DiNi is designed to perform optimally every day, whatever your surveying job. It is built rugged—with a dust- and waterproof rating of IP55—to take the tough conditions of the job site in its stride. A backlight in the screen and a light in the circular bubble keep you productive even when daylight gets low.

The DiNi will operate for three days without requiring a battery change, then when it does just recharge it as you would your Trimble GNSS system battery...the batteries are the same to ensure convenience and productivity.

When a job is complete, easily transfer data from the instrument to a computer by using a USB storage device; You don't have to carry your instrument in to the office.

EASY TO LEARN, EASY TO USE

The Trimble DiNi Digital Level demands the industry's smallest measurement field—just 30 cm of code rod. So you can measure greater change in height between the level and the rod in one setup, and save time. Additionally, the small measurement area:

- reduces the number of stations needed by up to 20% because the Trimble DiNi is less impacted by a rod hidden by vegetation or hilly terrain.
- makes leveling in low light conditions, for example, in tunnels, easier because only a very small part of the staff needs to be illuminated.
- ensures greater accuracy through less influence of refraction near the ground.

The large graphical display of the Trimble DiNi is also unique, and is complemented by the latest Trimble keyboard for easy operation. Crew members used to operating other Trimble systems will easily adapt to the Trimble DiNi.

TRIMBLE QUALITY AND ACCURACY FOR MEASURING WITH CONFIDENCE

The Trimble DiNi Digital Level is designed to support the rest of Trimble's Integrated Surveying portfolio. The Trimble DiNi interface is based on Trimble's other advanced and field-proven controllers for easy adoption of the instrument by your crews. Proven Optics by Carl Zeiss ensure the Trimble DiNi offers the highest precision and best resolution.

Measure with confidence, knowing that with the Trimble DiNi Digital Level, your crew will obtain the best quality results with the highest level of productivity.

Key Features

- Determine accurate height information via a quick and easy key press
- Eliminate errors and reduce rework with digital readings
- Enjoy effortless data transfer between instrument and office
- Measure to a measurement field of just 30 cm
- Level 60% faster than with conventional automatic leveling

Trimble DiNi DIGITAL LEVEL

PERFORMANCE SPECIFICATIONS

Accuracy . . . DIN 18723, standard deviation height measuring per 1 km (3280.84 ft) of double leveling

Trimble DiNi 0.3 mm per km

Electronic measurement
- Invar precision bar code staff . . . 0.3 mm (0.001 ft)
- Standard bar code staff . . . 1.0 mm (0.004 ft)

Visual measurement . . . 1.5 mm (0.005 ft)

Distance measurement . . . with a 20 m (65.62 ft) sighting distance
- Invar precision bar code staff . . . 20 mm (0.066 ft)
- Standard bar code staff . . . 25 mm (0.082 ft)
- Visual measurements . . . 0.2 m (0.656 ft)

Trimble DiNi 0.7 mm per km

Electronic measurement
- Invar precision bar code staff . . . 0.7 mm (0.002 ft)
- Standard bar code staff . . . 1.3 mm (0.004 ft)
- Visual measurement . . . 2.0 mm (0.007 ft)

Distance measurement . . . with a 20 m (65.62 ft) sighting distance
- Invar precision bar code staff . . . 25 mm (0.082 ft)
- Standard bar code staff . . . 30 mm (0.098 ft)
- Visual measurement . . . 0.3 m (0.984 ft)

Range

Electronic measurement . . . 1.5 m–100 m (4.92 ft–328.08 ft)
Visual measurement . . . from 1.3 m (4.265 ft)

Electronic measurement

Trimble DiNi 0.3 mm per km

- Resolution height measurement . . . 0.01 mm / 0.0001 ft / 0.0001 in
- Resolution distance measurement . . . 1 mm (0.003 ft)
- Measurement time . . . 3 s

Trimble DiNi 0.7 mm per km

- Resolution height measurement . . . 0.1 mm / 0.001 ft / 0.001 in
- Resolution distance measurement . . . 10 mm (0.033 ft)
- Measurement time . . . 2 s

Horizontal Circle

Type of graduation . . . 400 grads and 360 deg
Graduation interval . . . 1 grad and 1 deg
Estimation to . . . 0.1 grad and 0.1 deg

Measurement Programs

Trimble DiNi 0.3 mm per km

Standard programs . . . Single measurement with and without stationing, stakeout, line leveling with intermediate sight and stakeout, line adjustment
Leveling methods[1] . . . BF, BFFB, BFBF, BBFF, FBBF aBF, aBFFB, aBFBF, aBBFF, aFBBF

Trimble DiNi 0.7 mm per km

Standard programs . . . Single measurement with and without stationing, stakeout, line leveling with intermediate sight and stakeout
Leveling methods . . . BF, BFFB, aBF, aBFFB

ENVIRONMENTAL

Operating temperature . . . –20 °C to +50 °C (–4 °F to 122 °F)
Dust- and waterproofing . . . IP55

GENERAL SPECIFICATION

Telescope

Aperture . . . 40 mm (0.131 ft)
Field of view at 100 m . . . 2.2 m (7.217 ft)
Electronic measurement field . . . 0.3 m (0.984 ft)
Magnification
- Trimble DiNi 0.3 mm per km . . . 32 x
- Trimble DiNi 0.7 mm per km . . . 26 x

Compensator

Inclination range . . . ±15'
Setting accuracy
- Trimble DiNi 0.3 mm per km . . . ±0.2"
- Trimble DiNi 0.7 mm per km . . . ±0.5"

Circular level . . . 8'/2 mm with Illumination

Display . . . Graphical, 240 x 160 pixels, monochrome with illumination

Keyboard . . . 19-key alpha-numeric and 4-way arrow key for navigation\

Recording

Internal memory . . . up to 30 000 data lines
External memory . . . USB Flash Drive support
Data transfer . . . USB Interface for data transfer between DiNi and PC (means two way communication)
Real-time clock and temperature sensor
- Trimble DiNi 0.3 mm per km . . . Recording of time or temperature
- Trimble DiNi 0.7 mm per km . . . N.A.

Power supply
- Internal battery . . . Li-Ion, 7.4 V / 2.4 Ah
- Operating time . . . 3 days working time without illumination

Weight (including battery) . . . 3.5 kg (7.72 lb)

1 F = Foresight, B = Backsight, a = alternating
Certified quality in accordance with DIN ISO 9001/EN 29001.

Specifications subject to change without notice.

Contact your local Trimble Authorized Distribution Partner for more information

NORTH AMERICA
Trimble Inc.
10368 Westmoor Dr
Westminster CO 80021
USA

EUROPE
Trimble Germany GmbH
Am Prime Parc 11
65479 Raunheim
GERMANY

ASIA-PACIFIC
Trimble Navigation
Singapore Pty Limited
80 Marine Parade Road
#22-06, Parkway Parade
Singapore 449269
SINGAPORE

Certificate

TRIMBLE DiNi WITH SERIAL NUMBER 752150
COMPLIES WITH THESE SPECIFICATIONS:

HEIGHT MEASUREMENT

Accuracy *electronic measurements*	
(Standard deviation for 1 km two-way levelling based on DIN 18723)	
Precise levelling rod, coded scale:	0.3 mm (0.001 ft)
Engineer's folding staff, coded scale:	1.0 mm (0.003 ft)
Compensator	
Working range of:	± 270 mgon (± 15')
Setting accuracy:	±0.06 mgon (± 0.2")

DISTANCE MEASUREMENT

Accuracy *electronic measurements*	
Leveling mode	
(0.3 m staff intercept, range 20 m)	
Precise leveling rod, coded scale:	20 mm (0.066 ft)
Engineer's folding staff, coded scale	25 mm (0.082 ft)

MEASURING RANGE

Electronic measurement	**Range:**
Precise leveling rod, coded scale:	1.5 - 100 m (5 ft – 330 ft)
Engineer's folding staff, coded scale	1.5 - 100 m (5 ft – 330 ft)

Trimble instrument type Trimble DiNi has been tested and complies with the original specification. Tests have been conducted over established horizontal collimator height differences and baselines which have been calibrated with special Ni 002 levelling instrument by Carl Zeiss Jena in regular intervals. All procedures are documented in accordance with ISO 9001 issued by DQS, Germany.

L. Stiegler

Linda Stiegler, Inspector
January 21st, 2020 Jena, Germany

Trimble

Technical data

Height measurements
Standard deviation per km double run (ISO 17123-2):

Electronic measurement	DNA03	DNA10
with invar staff	0.3mm	0.9mm
with standard staff	1.0mm	1.5mm
Optical measurement	2.0mm	2.0mm

Distance measurement
Standard deviation 5mm/10m

Distance measuring range for electronic measurements

Staff lengths ≥ 3m	1.8m - 110m
Recommendation for 3m invar staffs	1.8m - 60m
Staff lengths = 2.7m	1.8m - 100m
Staff lengths = 1.82m/ 2m	1.8m - 60m
Measuring time single measure	typically 3 sec.

Telescope

Magnification	24x
Free objective diameter	36mm
Opening angle	2°
Field of view	3.5m at 100m
Min. target distance	0.6m
Multiplication constant	100
Addition constant	0

Level sensitivity
Circular level 8'/2mm

Compensator
Magnet damped pendulum compensator with electronic range control.

Slope angle		~± 10'
Centering accuracy	DNA03	DNA10
Standard deviation	0.3"	0.8"

Display

LC display	8 lines of 24 characters, 144 x 64 pixels
Lighting	economic/ permanent/ circular level only

Heating	on/off switch, sets in below -5°C

Dimensions

Instrument	
Height (incl. hand grip)	168mm +/-5mm
Width	
on the side drives	240mm
instrument body	206mm
Length	210mm
Container	468 x 254 x 355mm (L x B x H)

Weight

incl. battery GEB111	2.85kg

Measured values corrections

Collimation error correction	automatically
Earth curvature correction	on/off switch; level probe with correction

Record

Internal storage	approx. 6000 measurements or about 1650 stations (BF)
Serial interface RS232	from "Measure & Record" in GSI-8/16-format
Data backup	PCMCIA-card (flash, SRAM), up to 32MB capacity

Temperature range

Storage:	-40°C - +70°C
Operation	-20°C - +50°C

Environmental conditions

Water and dust-proof	IP53 (acc. IEC60529)
Humidity	up to 95% humidity no condensation

Magnetic field sensitivity

Line-of-sight difference in horizontal constant magnetic field at a field strength of 0μT up to ±400μT [4 Gauss].	≤ 1"

Battery powered

Batteries (NiMh)	**GEB111**	**GEB121**
Voltage	6V	6V
Capacity	1800mAh	3600mAh
Operating life DNA	12h	24h
Battery adapter GAD39	only for Alkaline batteries, 6 x LR6/AA/AM3, 1.5V	

Trimble S7

TOTAL STATION

THE MOST PRODUCTIVE TOTAL STATION

The Trimble® S7 Total Station combines scanning, imaging and surveying into one powerful solution. Now you only need one instrument on the job site to perform all your data capture. Create 3D models, high accuracy visual site documentation, point clouds, and more using the Trimble S7, Trimble Access™ field software and Trimble Business Center office software.

The Trimble S7 is the ultimate system for efficient surveying, allowing you to adapt to any situation and increasing your productivity in the field. The combination of SureScan, Trimble VISION™, FineLock™ and DR Plus technology, along with many other features, means you'll be able to collect data faster and more accurately than ever before.

Integrated 3D Scanning

Save time in the field and in the office with Trimble SureScan technology. Now you have the flexibility to perform feature-rich scans every day. Efficiently capture the information you need to create digital terrain models (DTMs), perform volume calculations and make topographic measurements faster than with traditional surveying methods. SureScan technology enables you to collect and process data faster by focusing on collecting the right points, not just more points.

Improved Trimble VISION Technology

Trimble VISION technology gives you the power to direct your survey with live video images on the controller as well as create a wide variety of deliverables from collected imagery. Capture measurements to prisms or reflectorless with point-and-click efficiency via video. Quickly document your site and add notes directly to the pictures in the field to ensure you never miss that critical information. Back in the office, you can use your Trimble VISION data for measurements, or to process 360-degree panoramas and high dynamic range (HDR) images for even clearer deliverables.

Superior Accuracy with Trimble DR Plus

Trimble DR Plus range measurement technology provides extended range of Direct Reflex measurement without a prism. Now you can you measure further with fewer instrument set-ups and enhance your scanning performance. Trimble DR Plus, combined with the smooth and silent MagDrive™ servo technology, creates unmatched capability for quick measurements, without compromising on accuracy.

Manage Your Assets

Know where your total stations are 24 hours a day with Trimble Locate2Protect technology. See where your equipment is at any given time and get alerts if your instrument leaves a job site or experiences unexpected equipment shock or abuse.

Trimble InSphere™ Equipment Manager lets you view usage and keep up-to-date on firmware, software and maintenance requirements. With Trimble Locate2Protect and InSphere Equipment Manager, you can rest assured knowing your equipment is up-to-date and where it should be.

Powerful Field and Office Software

Choose from a variety of Trimble controllers operating the feature rich, intuitive Trimble Access field software. Streamlined workflows like Roads, Utilities and Pipelines guide crews through common project types, helping to get the job done faster with less distractions. Trimble Access workflows can also be customized to fit your needs.

Back in the office, trust Trimble Business Center to help you check, process and adjust your optical and GNSS data in one software solution.

Key Features

- Surveying, imaging and 3D scanning in one powerful solution
- Improved Trimble VISION technology for video robotic control, scene documentation and photogrametric measurements
- Locate2Protect real-time equipment management
- Trimble DR Plus for long range and superior accuracy
- Intuitive Trimble Access Field Software
- Trimble Business Center Office Software for quick data processing
- Seamless integration with the Trimble V10 Imaging Rover and GNSS receivers

PERFORMANCE

Angle measurement

Sensor type ..... Absolute encoder with diametrical reading
Accuracy (Standard deviation based on DIN 18723) ..... 1" (0.3 mgon)
2" (0.6 mgon), 3" (1.0 mgon), or 5" (1.5 mgon)
Display (least count) ..... 0.1" (0.01 mgon)
Automatic level compensator
Type ..... Centered dual-axis
Accuracy ..... 0.5" (0.15 mgon)
Range ..... ±5.4' (±100 mgon)

Distance measurement

Accuracy (ISO)
Prism mode
Standard[1] ..... 1 mm + 2 ppm (0.003 ft + 2 ppm)
Accuracy (RMSE)
Prism mode
Standard ..... 2 mm + 2 ppm (0.0065 ft + 2 ppm)
Tracking ..... 4 mm + 2 ppm (0.013 ft + 2 ppm)
DR mode
Standard ..... 2 mm + 2 ppm (0.0065 ft + 2 ppm)
Tracking ..... 4 mm + 2 ppm (0.013 ft + 2 ppm)
Extended range ..... 10 mm + 2 ppm (0.033 ft + 2 ppm)

Measuring time

Prism mode
Standard ..... 1.2 sec
Tracking ..... 0.4 sec
DR mode
Standard ..... 1–5 sec
Tracking ..... 0.4 sec

Measurement range

Prism mode[5, 6]
1 prism ..... 2,500 m (8,202 ft)
1 prism Long Range mode ..... 5,500 m (18,044 ft) (max. range)
Shortest possible range ..... 0.2 m (0.65 ft)
DR mode

	Good (Good visibility, low ambient light)	**Normal** (Normal visibility, moderate unlight, some heat shimmer)	**Difficult** (Haze, object in direct sunlight, turbulence)
White card (90% reflective)[3]	1,300 m (4,265 ft)	1,300 m (4,265 ft)	1,200 m (3,937 ft)
Gray card (18% reflective)[3]	600 m (1,969 ft)	600 m (1,969 ft)	550 m (1,804 ft)

Reflective foil 20 mm ..... 1,000 m (3,280 ft)
Shortest possible range ..... 1 m (3.28 ft)
DR Extended Range Mode
White Card (90% reflective)[3] ..... 2,200 m

Scanning

Range[2, 3] ..... from 1 m up to 250 m (3.28 ft–820 ft)
Speed[4] ..... up to 15 points/sec
Minimum point spacing ..... 10 mm (0.032 ft)
Standard deviation ..... 1.5 mm @ ≤50 m (0.0049 ft @ ≤164 ft)
Single 3D point accuracy ..... 10 mm @ ≤150 m (0.032 ft @ ≤492 ft)

EDM SPECIFICATIONS (DR PLUS)

Light source ..... Pulsed Laser diode 905 nm; Laser class 1
Beam divergence
Horizontal ..... 2 cm/50 m (0.06 ft/164 ft)
Vertical ..... 4 cm/50 m (0.13 ft/164 ft)

SYSTEM SPECIFICATIONS

Leveling

Circular level in tribrach	8'/2 mm (8'/0.007 ft)
Electronic 2-axis level in the LC-display with a resolution of	0.3" (0.1 mgon)

Servo system

MagDrive servo technology	Integrated servo/angle sensor electromagnetic direct drive
Rotation speed	115 degrees/sec (128 gon/sec)
Rotation time Face 1 to Face 2	2.6 sec
Positioning speed180 degrees (200 gon)	2.6 sec
Clamps and slow motions	Servo-driven, endless fine adjustment

Centering

Centering system	Trimble 3-pin
Optical plummet	Built-in optical plummet
Magnification focusing distance	2.3×/0.5 m to infinity (1.6 ft to infinity)

Telescope

Magnification	30×
Aperture	40 mm (1.57 in)
Field of view at 100 m (328 ft)	2.6 m at 100 m (8.5 ft at 328 ft)
Focusing distance	1.5 m (4.92 ft) to infinity
Illuminated crosshair	Variable (10 steps)
Autofocus	Standard

Camera

Chip	Color Digital Image Sensor
Resolution	2048 x 1536 pixels
Focal length	23 mm (0.09 ft)
Depth of field	3 m to infinity (9.84 ft to infinity)
Field of view	16.5° x 12.3° (18.3 gon x 13.7 gon)
Digital zoom	4-step (1x, 2x, 4x, 8x)
Exposure	Spot, HDR, Automatic
Brightness	User-definable
Image storage	Up to 2048 x 1536 pixels
File format	JPEG
Compression ratio	User-definable
Video streaming[8]	5 frames/sec

Power supply

Internal battery	Rechargeable Li-Ion battery 11.1 V, 5.0 Ah
Operating time[9]	
One internal battery	Approx. 6.5 hours
Three internal batteries in multi-battery adapter	Approx. 20 hours
Robotic holder with one internal battery	Approx. 13.5 hours
Operating time for video robotic[9]	
One battery	5.5 hours
Three batteries in multi-battery adapter	17 hours

Weight and dimensions

Instrument	5.5 kg (11.57 lb)
Trimble CU controller	0.4 kg (0.88 lb)
Tribrach	0.7 kg (1.54 lb)
Internal battery	0.35 kg (0.77 lb)
Trunnion axis height	196 mm (7.71 in)

Other

Laser pointer coaxial	Laser class 2
Operating temperature	–20 °C to +50 °C (–4 °F to +122 °F)
Dust and water proofing	IP65
Communication	2.4 GHz, USB, Serial, Bluetooth®[10]
Security	Dual-layer password protection, Locate2Protect[11]

Trimble S7 TOTAL STATION

AUTOLOCK AND ROBOTIC SURVEYING

Autolock and Robotic Range[6]
- Passive prisms . . . . . 500–700 m (1,640–2,297 ft)
- Trimble MultiTrack Target . . . . . 800 m (2,625 ft)
- Trimble ActiveTrack 360 Target . . . . . 500 m (1,640 ft)

Autolock pointing precision at 200 m (656 ft) (Standard deviation)[5]
- Passive prisms . . . . . <2 mm (0.007 ft)
- Trimble MultiTrack Target . . . . . <2 mm (0.007 ft)
- Trimble ActiveTrack 360 Target . . . . . <2 mm (0.007 ft)

Shortest search distance . . . . . 0.2 m (0.65 ft)
Type of radio internal/external . . . . 2.4 GHz frequency-hopping, spread-sprectrum radios

Search time (typical)[7] . . . . . 2–10 sec

FINELOCK

Pointing precision at 300 m (980 ft)
- (standard deviation)[6] . . . . . <1 mm (0.003 ft)
- Range to passive prisms (min–max)[6] . . . . . 20 m–700 m (64 ft–2,297 ft)

Minimum spacing between prisms
- at 200 m (656 ft) . . . . . 0.8 m (2.625 ft)

GPS SEARCH/GEOLOCK

GPS Search/GeoLock . . . . . 360 degrees (400 gon) or defined horizontal and vertical search window
Solution acquisition time[12] . . . . . 15–30 sec
Target re-acquisition time . . . . . <3 sec
Range . . . . . Autolock & Robotic range limits

1 Standard deviation according to ISO17123-4.
2 Target color, atmospheric conditions, and scanning angles will impact range.
3 Kodak Gray Card, Catalog number E1527795.
4 Target shape, texture, and color; grid size; and distance and angle to target; will impact speed.
5 Standard clear: No haze. Overcast or moderate sunlight with very light heat shimmer.
6 Range and accuracy depend on atmospheric conditions, size of prisms and background radiation.
7 Dependent on selected size of search window.
8 0.5 frames per second with remote operation.
9 The capacity in –20 °C (–5 °F) is 75% of the capacity at +20 °C (68 °F).
10 Bluetooth type approvals are country specific.
11 Functionality and availability dependent on region.
12 Solution acquisition time is dependent upon solution geometry and GPS position quality.

Specifications subject to change without notice.

Contact your local Trimble Authorized Distribution Partner for more information

NORTH AMERICA
Trimble Navigation Limited
10368 Westmoor Drive
Westminster CO 80021
USA

EUROPE
Trimble Germany GmbH
Am Prime Parc 11
65479 Raunheim
GERMANY

ASIA-PACIFIC
Trimble Navigation
Singapore Pty Limited
80 Marine Parade Road
#22-06, Parkway Parade
Singapore 449269
SINGAPORE

称及含量 ces or Elements in Products) 害物质 us Substance)		
六价铬 (Cr6+)	多溴联苯 (PBB)	多溴联苯醚 (PBDE)
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26572规定的限量要求以下。

GB/T 26572规定的限量要求。

CE

Declaration of Conformity

Issuer's name: **Trimble AB**
P.O. Box 64
SE-182 11 Danderyd
Sweden

Object of declaration: **Trimble SPS Series Total Stations**

Config. / Sales p/.n	Base p/n.	Description
SPS620552210	58412045	SPS620 DR Plus, 5"/5"
SPS720252210	58412045	SPS720 DR Plus, 3"/2"
SPS730252210	58485021	SPS 730 DR Plus, 3"/2" (without Machine control option)
SPS730252200	58485021	SPS 730 DR Plus, 3"/2" (with Machine control option)
SPS930152210	58485021	SPS 930 DR Plus, 1"/1" (without Machine control option)
SPS930152200	58485021	SPS 930 DR Plus, 1"/1" (with Machine control option)

This declaration of conformity is issued under the sole responsibility of the manufacturer. The object of declaration described above is in conformity with the essential requirements of directives 2006/42/EC (MD), 2014/53/EU (RED) and 2011/65/EU (RoHS), including its subsequent amendments, based on the following European harmonised standards:

- **EN ISO 12100: 2010**
- **EN 60825-1: 2014**
- **EN 61326-1: 2013**
- **EN 62311: 2008**
- **EN 61010-1: 2010**
- **EN 301 489-1 V2.1.1**
- **EN 301 489-17 V3.1.1**
- **EN 300 328 V2.1.1**

FW versions: M3.X and C10.X . For detailed information how compliance with the above directives are fulfilled, see Technical File SPS_TF located at Trimble AB in Danderyd.

Signed for and on behalf of: Trimble AB
Date: April 8, 2020

.....
Malin Siberg, Manager of Engineering

Trimble.

Doc no. 57005021 Rev. J

Certificate

TRIMBLE SPS930 1"/1" DR Plus WITH SERIAL NUMBER 72632025
COMPLIES WITH THESE SPECIFICATIONS:

ANGLE MEASUREMENT

Accuracy *(Standard deviation based on DIN 18723):* 1" (0.3 mgon)
Automatic level compensator
Dual-axis with a working range of: ±5.4' (±100 mgon)

DISTANCE MEASUREMENT

Prism mode
Accuracy (ISO 17123-4) 1 mm + 2 ppm
Accuracy (RMSE): 2 mm + 2 ppm

DR mode
Accuracy (RMSE): 2 mm + 2 ppm

RANGE

Prism mode
1 prism: 0.2 m - 5,500 m

DR mode
Kodak Grey (18%): 1 m - 600 m

For full specifications of this instrument see Datasheet that is available on www.trimble.com

The Trimble AB Sweden facility is certified to ISO 9001:2015

Magnus Stråhle, Inspector
February 2 2021, Danderyd, Sweden

Trimble®

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wood.

Appendix D
Existing Bridge Settlement Estimate Calculations

wood.

JOB NO. PS19203160

COMPUTED BY B. Lien / M. Sabbagh

PROJECT I-405 – Existing May Creek Bridge

DATE Oct 15, 2021

SUBJECT Settlement estimates of existing footings due to pile driving

CHECKED BY R. Hillaby DATE 10/15/2021

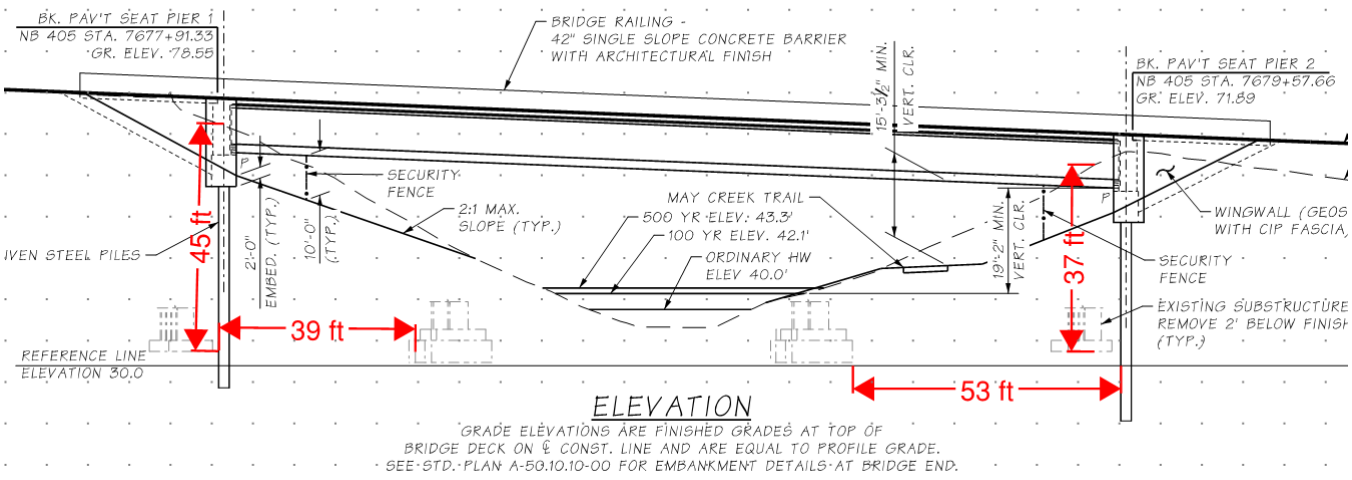
1.0 PURPOSE

- Calculate settlement of the existing May Creek bridge footings resulting from pile driving operations for the replacement bridge.
- The following reference was used for the settlement estimates of the existing bridge footings:

  Massarsch, K.R. and Fellenius, B.H. 2014. Ground Vibrations from Pile and Sheet Pile Driving Part 1 – Building Damage. Proceedings, DFI/EFFC International Conference on Piling and Deep Foundations, Stockholm, May 21 – 23, 2014, pp. 131 - 139.

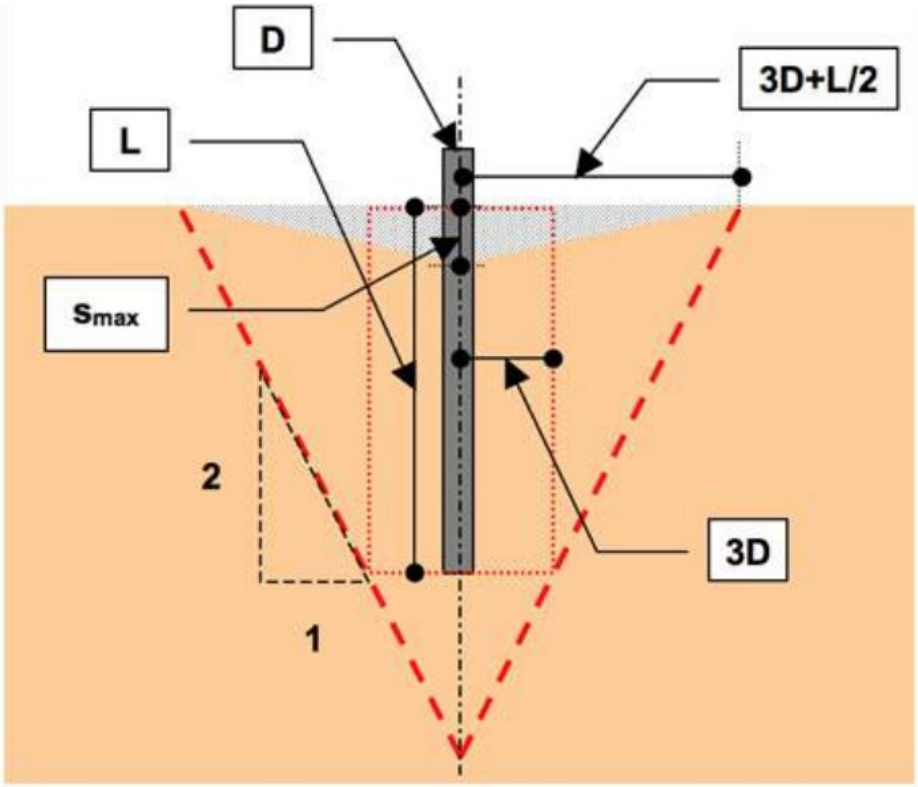
2.0 EXISTING CONDITIONS:

- Below is a snapshot of the existing bridge.



- Based on the existing subsurface conditions, it is understood that the footings of the existing bridge are founded on the ESU # 4A unit, which consists of dense to very dense sand and gravel (glacially overriden advance outwash).
- The 2.5-ft diameter driven piles for the new bridge are presently designed to be 60 feet deep below the ground surface.
- The pile driving level of energy is considered to be medium to high.

3.0 SETTLEMENT CALCULATIONS



- The zone of influence laterally from the driven pile is 3D + L/2 = 3*2.5 + 60/2 = 37.5 feet. The vertical zone of influence extends to 2*37.5 = 75 feet below the ground surface.
- Assuming homogeneous ground conditions all the way to the ground surface, the maximum settlements of the ground adjacent to the pile can be calculated as:

$$s_{max} = \alpha(L+6D);$$

Where α is the soil compressions factor that can be estimated from Table 1 of the article.

TABLE 1 Compression factor, α, for sand based on soil relative density and level of driving energy.

Ground Vibrations:	Low	Medium	High
Soil Density	----- Compression factor, α -----		
Very loose	0.02	0.03	0.04
Loose	0.01	0.02	0.03
Medium	0.005	0.01	0.02
Dense	0.00	0.005	0.01
Very dense	0.00	0.00	0.005

- Since the soil under the existing bridge footings is dense to very dense, and considering that the pile driving imposes a medium to high level of energy, a compression factor of 0.005 was considered.
- Therefore S_{max} = 0.005*(60+6*2.5) = 0.375 feet = 4.5 inches
- The existing Pier 1 (see Section 2.0 of this calc package) is 45 feet below the ground surface and approximately 5 feet away from the nearest driven pile. Therefore, the settlement of the footing can be prorated both vertically and laterally and estimated as: 4.5 * (30/75) * (10/15) = 1.2 inch.
- For the interior footing next to Pier 1, the settlement of the footing will be negligible since it is located outside the cone influence (39 feet away from the driven pile, which is greater than 37.5 feet).
- The existing Pier 2 is 37 feet below the ground surface and approximately 5 feet away from the nearest driven pile. Therefore, the settlement of the footing can be prorated both vertically and laterally and estimated as: 4.5 * (38/75) * (14/19) = 1.7 inch.
- For the interior footing next to Pier 2, the settlement of the footing will be negligible since it is located outside the cone influence (53 feet away from the driven pile, which is greater than 37.5 feet).

4.0 CONCLUSION:

- The calculated existing bridge footing settlements due to the pile driving activities are anticipated to be less than 2 inches. As a result, based on the RFP Section 2.6.7.5, we note that settlement monitoring is not required since the settlements are predicted to be less than 2 inches. Therefore no settlement action and alert levels are required.

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Appendix E
Instrumentation and Optical Survey Data Reporting Samples

78-INCH SANITARY SEWER MAIN VIBRATION AND SETTLEMENT MONITORING REPORT

Project: I-405 Renton to Bellevue ETL and Widening
Address: 4660 Ripley Ln N Renton, WA 98056

REPORT DETAILS

Start Time: 7/12/2021 End Time: 7/16/2021

Report Author: Henrik Labreche

Daily Report
X Weekly Report
Monthly Report

WORK ACTIVITIES

Morning (before 12pm):

Construction access adjacent to 78in sewer was used by loaded solo trucks

Afternoon (after 12pm):

Construction access adjacent to 78in sewer was used by loaded solo trucks

Alert/Action Level Exceedance Justification (see thresholds at bottom of page)

none

Other Observations

none

ATTACHMENTS

Settlement Monitoring Data

Vibration Data

Strain Gauge Inspection

Vibration Monitoring

Alert/Action Level - 0.5 in/s PPV continuous
1.5 in/s PPV discontinuous: Instrumentation Specialist to notify contractor to stop work and modify construction methods.

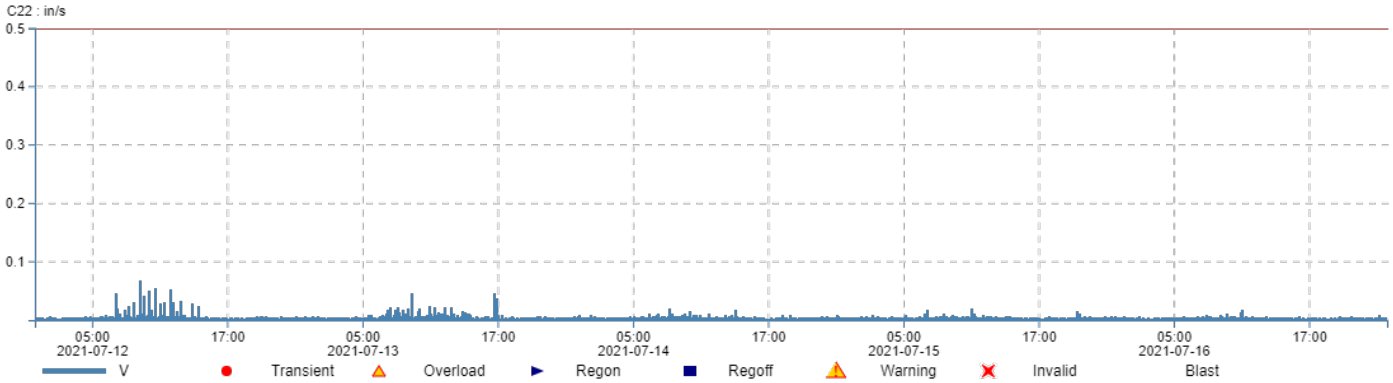
Settlement Monitoring

Action Level - 1/4": Surveyor to notify contractor to stop work and modify construction methods as required. King County and WSDOT to be notified via email within 24 hours

Alert Level - 3/16": Surveyor to alert contractor immediately

Interval report

Project	I-405 Renton to Bellevue Design-Build
Project maintainer	Christina Hernandez
Time frame	2021-07-12 00:00 - 2021-07-16 23:59 (America/Los_Angeles)
Measure point	MP_1
Location	Sanitary Sewer Pipe
Sensor type	C22
Serial no.	106018
Master(s) serial no.	106018
Latest calibration	2021-02-12
Standard	ISEE Seismograph 10 in/s 2-250Hz
Unit	in/s
Quantity	Velocity
Interval time	10 min
Frequency weighting	OFF
Max	V: 0.066 in/s



X-span	2021-07-12 00:00:00 - 2021-07-16 23:59:00
Y-span	C22 : in/s: 0.0 - 0.50
	V
Max	0.066 in/s
Date	2021-07-12
Time	09:20:00

Optical Monitoring Data Reporting Sample

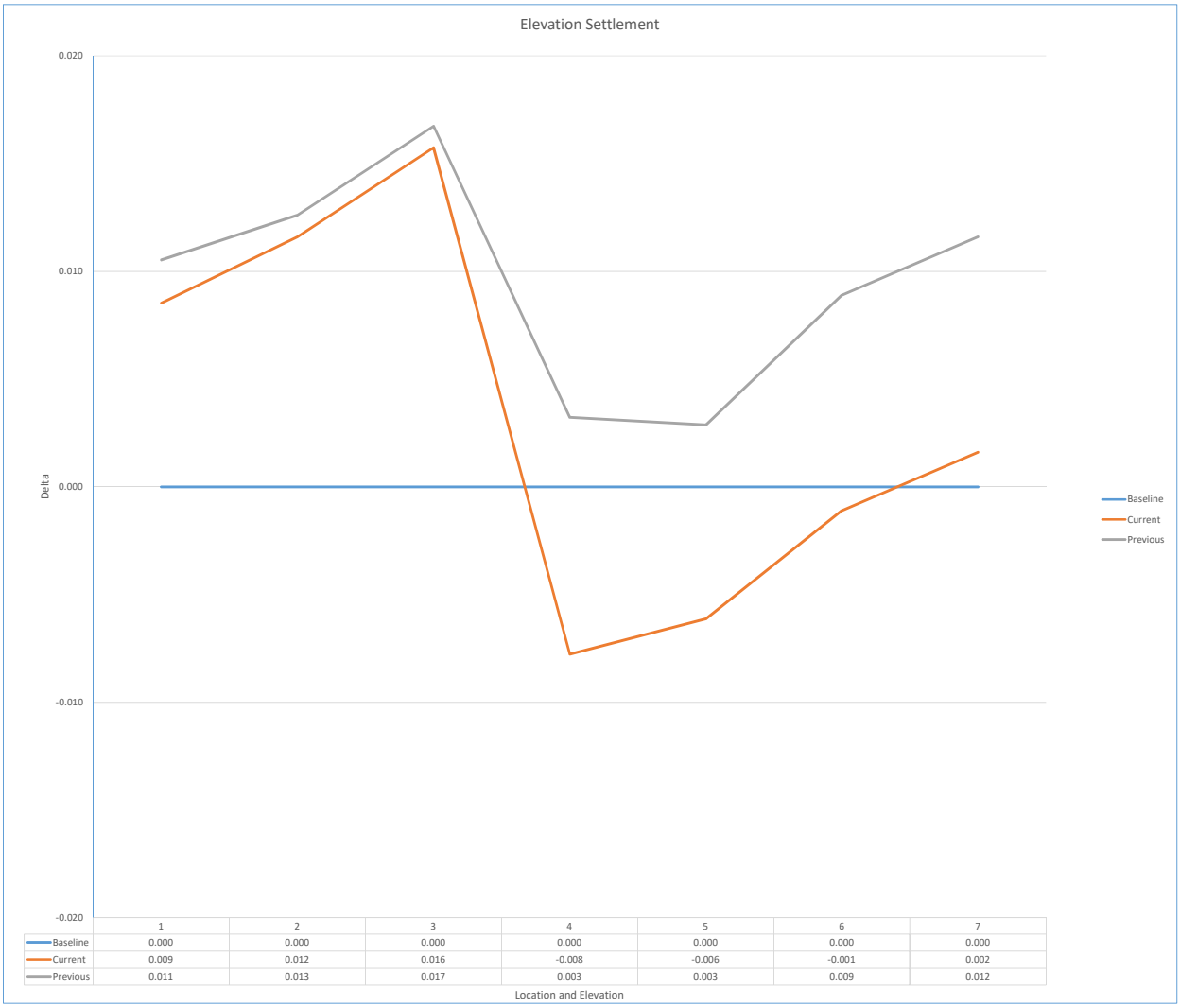
Sample Reporting Format
Wall/Embankment _____ Settlement Monitoring Report

Surveyor:
Total Station: **S/N:**
Digital Level: **S/N:**
Time:
Temperature:
Weather Conditions:
Work Activity:

Basline Survey : MM/DD/YYYY				
Pt#	**N**	**E**	**Elevation**	**Location**
				MP-1-7.10R
				MP-1A-7.10R

Delta Survey : MM/DD/YYYY				
Pt#	**N**	**E**	**Elevation**	**Location**
				MP-1-7.10R
				MP-1A-7.10R

Optical Monitoring Data Reporting Sample



	1	2	3	4	5	6	7
Baseline	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Current	0.009	0.012	0.016	-0.008	-0.006	-0.001	0.002
Previous	0.011	0.013	0.017	0.003	0.003	0.009	0.012

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Appendix F
Resumes of Key Staff

DAVID EVANS AND ASSOCIATES INC.

(Keith) Craig Moore, PLS, PSM | Survey Project Manager

Craig has more than 40 years of experience in the surveying field. His experience includes geometry control for fabrication and erection of precast concrete segments. Craig has held a supervisory position in the construction industry for 30 years. He has a record of success overseeing surveying on multimillion-dollar heavy civil, infrastructure, and commercial development projects for government and private-sector clients. His experience includes managing crews of up to 20 in highway/bridge, light rail, airport, high-rise, and a variety of other construction/land survey projects. Craig has a broad range of monitoring experience on Commercial and Heavy Civil projects, performing Monitoring on High Rise Structures, Ground Settlement, Temporary/Permanent Shoring, Formwork, Foundations, Utilities, and Bridges.

Experience

I-5/SR16 HOV Connector Design-Build Project, for WSDOT, Tacoma, Washington
As Survey Manager, Craig was responsible for subcontracts and survey on the highway and bridge Design-Build construction project. He managed implementation of Survey Controls, GPS, and Quality Control and Assurance. Craig was the Contractor's Task Force Lead on Roadway Design and worked on various Design Teams.

South 200th South Link S440 Design-Build Project, Sound Transit, SeaTac, Washington
As Survey Manager on the 1.6-mile Light Rail Design-Build project, Craig managed precast yard and site survey for the segmental span-by-span, balanced cantilever, and station facility on the light rail project at the SeaTac Airport. Tasks included Survey Controls for Structures, Settlement Monitoring of Utilities and Structures, and QA, QC oversight.

SR 520 Eastside Transit, HOV Design-Build Project, for WSDOT, Bellevue, Washington
Craig was the Survey Manager for this signature Design-Build project. The scope of this project involved over 2.5 miles of road widening to accommodate a new Eastbound HOV lane and wider shoulders, three large structural concrete lids and a new direct access interchange at Bellevue Way/108th Avenue for transit and HOV. Craig was responsible for contracts and management of survey including implementation of GPS, Machine Controls, Settlement Monitoring oversight and Quality Control and Assurance.

Central Link Light Rail C755 and C410, for Sound Transit, Tukwila, Washington
Craig was Survey Manager on this project consisting of precast elevated segmental structures, at grade sections, roadway, station facility, plinths and track. The structure is a precast segmental design using two different procedures for erection of segments; span-by-span and balanced cantilevers. Craig was responsible for contracts and management of survey including performance of Substructure and Superstructure Precast erection, utilities, and Settlement Monitoring of structures and temporary shoring, and Quality Control and Assurance.

Memorial Causeway Bridge, for the Florida DOT, Clearwater, Florida
Craig was Survey Manager for this VECP project over the Intracoastal Waterway consisting of segmental cast-in-place twin bridges, nine spans in all; four balanced cantilever constructed with a cast in place traveler; five constructed on false work. Craig was responsible for management of survey including Substructure and Superstructure erection, utilities, and Settlement Monitoring of structures and temporary shoring, and Quality Control and Assurance.

Education
Indian River Community College (Various AutoCAD and Surveying Classes) Fort, Pierce, FL, 1996-1998
American Traffic Safety Services Association: Certified Worksite Traffic Supervisor, 1995, Certified Traffic Control Supervisor, 1999
Dunwoody Industrial Institute, (Various AutoCAD and Surveying Classes) Minneapolis, MN, 1988-1989
Construction Surveying, Des Moines Area Community College, Des Moines, IA, 1979

Registration
Professional Surveyor and Mapper, Florida (LS 5981), 1999
Professional Land Surveyor, Washington (45167), 2008

Professional Affiliations
Florida Surveying and Mapping Society
Land Surveyors' Association of Washington
2011 Trustee - North Puget Sound Chapter
2012 Chapter President – North Puget Sound Chapter
2013 Trustee – North Puget Sound Chapter
2014 Chapter President – North Puget Sound Chapter
2015 Past President – North Puget Sound Chapter
2017 to current, Director – South Puget Sound Chapter

Years of Experience
40

DAVID EVANS AND ASSOCIATES INC.

I-4/St. John's River Design-Build Bridge, for the Florida DOT, Sanford, Florida
Craig was Survey Manager for the construction of a high level design-build bridge over the St. John's River northeast of Orlando. The Florida Bulb Tee superstructure is founded on concrete piling with cast-in-place footings, columns and caps. Each of the new bridges are 2,600 feet in length and have a maximum vertical clearance of 45 feet in the channel span.

Royal Park Temporary Bascule Design-Build Bridge, for the Florida DOT, West Palm Beach, Florida
Craig was the Survey Manager for the temporary 1,200-foot bascule bridge over the Intracoastal Waterway between West Palm Beach and The Town of Palm Beach. A steel frame was designed to support the bascule leafs on the temporary bridge. The 12-month schedule, included floating the bascule leaf components from the existing structure using the tides for lifting, eliminating the cost of renting a large water borne crane. The project was awarded the 2001 best design-build project in the civil sector (under $15 million) by the Design-Build Institute of America. As Surveyor Manager, Craig performed survey calculations, layout, and shoring and settlement monitoring.

Evans Crary Sr. Bridge, for the Florida DOT, Stuart, Florida
Craig was Survey Manager for this twin precast segmental structure that spanned the St. Lucie River. The bridges are 3,000 feet long, 50 feet wide with 180-foot spans, 17 in total, and a vertical clearance of 65 feet. Due to site conditions and a compressed schedule, a VECP was submitted to FDOT to change from balanced cantilever to span-by-span construction. As Surveyor Manager, Craig performed survey calculations, layout, shoring, and settlement monitoring.

Indiantown Road Bascule Bridge, for the Florida DOT, Jupiter, Florida
Craig was the Survey Manager and Traffic Control Supervisor for these twin bascule bridge structures over the Intracoastal Waterway. Features include 24-inch and 30-inch concrete piling foundations, and Florida Bulb T girder approaches with cast-in-place decks. Temporary and permanent MSE walls, sheet piling, asphalt and base completed the road work package. As Surveyor Manager, Craig performed survey calculations, layout, shoring, and settlement monitoring.

U.S. 41 Widening, for the Florida DOT, Sarasota, Florida
Craig was Project Surveyor on this widening project that consisted of 3 multi span flat slab bridges over Phillippi Creek. Other work included 3 miles of roadway with curb and gutter, asphalt and base widening, riprap, and signalization.

Natchez Trace Parkway Bridge, for the U.S. Department of Transportation (FHWA), Franklin, Tennessee
As the Project Surveyor, Craig was responsible for the Geometry Control on this double arch precast segmental bridge located over Route 96 in Tennessee's Natchez Trace Parkway. This project was featured in the July 26, 1999, issue of Engineering News-Record's 125 years Top Projects as the 1993 entry.

Denver International Airport Central Cores for Concourses A, B & C, City of Denver, Dept. of Aviation, Denver, Colorado
Craig was Field Engineer and Surveyor on the DIA Cores and Tunnels contract. The project consisted of three concourse structures connected with below-grade AGTS tunnels. It was the 1995 entry in the Engineering News-Record's July 26, 1999 issue on 125 Years Top Projects.

Dain Rauscher / Neiman Marcus Plaza (presently RBC Plaza), for Brookfield Office Properties, Minneapolis, Minnesota
Craig was the Surveyor on the 40-story retail and office tower in downtown Minneapolis. This one million-square-foot development provides a thirty five-story, 690,000 sq. ft. office building on a five-story, 240,000 sq. ft. retail podium. As the Surveyor, Craig performed survey layout, shoring monitoring, and quantity updates.

Principal Financial Building, for Principal Financial Group, Des Moines, Iowa
Craig was Field Engineer for the 12-story building in downtown Des Moines. Two skyways and two tunnels connect the new building to two adjacent buildings. As field engineer, Craig performed survey layout, shoring monitoring, and quantity updates.

Various Consulting Survey Firms in Iowa, Nebraska, and Minnesota
Early in his career, Craig worked for Consulting Survey firms on a multitude of public and private sector projects, developing plats, sectional, boundary, settlement monitoring, and plat surveying. His construction staking experience includes subdivision, commercial developments, and mainline pipeline and stations.